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A Catalogue of Environmental Quality Related Research in the Atlantic Region

Economic and Technical Review
Report EPS-3-AR-82-1

Atlantic Region

44

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A CATALOGUE OF ENVIRONMENTAL QUALITY RELATED RESEARCH IN THE ATLANTIC REGION

by

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Acknowledgements

This catalogue would not have been possible without the cooperation of the many researchers who so freely responded to our requests for information relating to their research activities.

Special thanks are extended to Larry Hildebrand and Peter Eaton of EPS for their editorial efforts and to Barb Pellerin for her patient typing of the many revisions to this catalogue.

1. INTRODUCTION

This report is an update and revision of the 1979 EPS publication "A Catalogue of Environmental Quality Data Sources in the Atlantic Provinces". The 1981 version attempts to summarize recent research efforts pertaining to environmental quality carried out in the Atlantic Region. Although assembled in response to a need within Environment Canada to be aware of the results of environmentally oriented research, it will hopefully be of service to scientists in the field or others involved in related regulatory activities.

Sources include universities, government departments, and research institutions. Research summaries were prepared from reports, papers, progress reports and verbal descriptions. As we were unable to contact everyone working in the field, and because of the variety of forms in which the information came to us, coverage is patchy or inadequate in some cases. If, however, the catalogue proves useful, and responses to the concept are favourable, it will be updated in the near future, resulting in a more comprehensive review of on-going environmental quality research.

Research summaries are organized into general subject categories numbered and indexed comprehensively at the back of the report. With the summaries are listed: a contact person, (not necessarily the main or only individual responsible), their affiliation, location and recent publications.

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1. Chlorinated Hydrocarbons in Sediments of the Atlantic Region.

Scientific Contact:
R. Pocklington, Atlantic Oceanographic Laboratory
Fisheries & Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

An investigation of concentrations of DDT and its derivates and PCBs in sediments of the Atlantic Region is part of the research program sponsored by the Ocean Dumping Control Act administration. This includes the development and testing of techniques for halogenated hydrocarbon analysis of marine samples.

Concentrations of ΣDDT (DDT plus DDE and TDE) and PCBs were below the detection limit (1 ppb ΣDDT, 5 ppb PCBs, dry weight) in more than half the surface sediment samples collected around the east coast. In one location, in the Bay of Chaleur only, were concentrations of 100 ppb ΣDDT found.

2. Organochlorine Compounds in White Shark (*Lamna nasus*) and Bluefin Tuna.

Scientific Contact:
V. Zitko, Fisheries and Oceans Canada
Saint Andrews, New Brunswick.

Samples of bluefin tuna were collected over the period 1976-1978, from an enclosure in St. Margarets Bay and analyzed (GC/MS) for HCB, PCBs, DDE, D, DDD, DDT, chlordane, nonochlors and other organochlorine compounds in the liver. Levels of PCBs, the DDT group, and in some cases dieldrin, were high. The concentrations of pesticides (D, DDD, DDT) decreased considerably since 1976. The concentration of DDE and PCB might have decreased slightly, but the concentration of HCB increased.

Some of the samples were examined by GC/MS. Chlordane and nonachlor were readily detectable in all these samples. In addition, the liver of a "sick" fish contained at least one additional minor component of technical chlordane, tentatively identified as a $CHCl_3$ adduct to chlordene, oxychlordane (a metabolite of chlordane), DDMU (a metabolite or degradation product of DDD), and a number of components of toxaphene. This is the first identification of toxaphene in fish from the West Atlantic. A number of other, as yet unidentified chlorinated compounds, were present as well.

The occurrence of toxaphene is not recent. Re-analysis of the liver of a white shark caught in 1971 indicates the presence of at least one component of toxaphene.

Publication:
V. Zitko, 1980. PCBs and other organochlorine compounds in sharks and tuna. ICES. C.M. 1980/E:21.

3. Pollution Trend Monitoring: Cod Study.

Scientific Contact:
J.F. Uthe, Fisheries and Oceans Canada
Halifax, Nova Scotia.

The between-year analyses have shown that the tissue levels of the following contaminants increased in 1978, compared to 1977: Hg (liver and muscle), Cd (liver), Se (liver), PCB (liver and muscle), Zn (liver) and Pb (liver). As (liver and muscle), hexachlorobenzene (liver) and pp^1-DDT (liver) decreased while Pb (muscle), Cu (liver and muscle), Zn (muscle) and HCB (liver) levels did not change.

Liver and muscle homogenates were prepared from the length-stratified 1979 cod sample, and analyses are underway. Pb determinations are being omitted since results indicate that Pb analyses offer little data of value. Of the organic contaminants only liver will be analyzed for hexachlorobenzene and PCBs.

4. Biocide and PCB Analysis.

Scientific Contact:
D. Stiles, Chemistry Department, Acadia University
Wolfville, Nova Scotia.

Analyses for organochlorine insecticides, various herbicides, and PCBs have been conducted on sediment and water samples taken from both marine and inland systems. Water quality determinations, including chemical and physical composition, have also been conducted on marine and inland systems.

5. Cadmium in Atlantic Canada.

Scientific Contact:
R.A.F. Matheson, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

Summary of data on levels of Cd in the environment, including water, sediment, soil, biota, air and industrial effluents. Sources are primarily federal and provincial government files and publications. Major sources of contamination are identified. High cadmium levels in sediments and lobsters from the harbour at Belledune are attributable to air and water emissions from the Brunswick Mining and Smelting lead smelter. Cadmium contamination of Dalhousie Harbour in the immediate area of the public wharf has resulted from the leaching of stored ore concentrate. Thermal power generation is another major source of Cd input in the region.

Publication:
Matheson, R.A.F. and D.J. Baker, 1980. Cadmium in the Atlantic Provinces. Surveillance Report EPS-5-AR-80-3, Atlantic Region.

6. Monitoring of Toxic Chemical Levels in Bird Eggs.

Scientific Contact:
P.A. Pearce, Canadian Wildlife Service
Environment Canada, Fredericton, New Brunswick.

The Canadian Wildlife Service participates in the ongoing national program to monitor toxic chemicals in marine bird eggs. 1980 was the tenth and final year of a monitoring program to measure organochlorine levels in the wing tissues of Woodcocks.

7. Cadium Contamination of Lobsters at Belledune Harbour.

Scientific Contact:
J.F. Uthe, Fisheries and Oceans Canada
Halifax, Nova Scotia.

In April, 1980 the Noranda Report documented high levels of Cd in lobsters from Belledune Harbour, and elevated Pb and Cd levels in mussels collected from within and surrounding the harbour. Since then, the geographical distribution of Cd levels in lobster digestive glands has been determined. Very high levels exist in the western part of the harbour, and geometric mean values decrease rapidly toward the harbour mouth and downstream of the harbour. Cd levels were sufficiently high to render digestive glands unfit for consumption in an area extending about 5 miles downstream of the harbour. Mean levels of Cd in hepatopancreas exceeded corresponding muscle means by 96 to 2560 times. Levels in tail muscle were considerably lower (3-10 times) than that of corresponding claw muscle.

Publication:

Uthe, J.F., C.L. Chou and D. Robinson, 1980. Cadmium in the American Lobster (*Homarus americanus*) from the area of Belledune Harbour IN: Cadmium Pollution of Belledune Harbour, New Brunswick, Canada. J.F. Uthe and V. Zitko (editors). Can. Tech. Rep. Fish. Aquat. Sci. No. 963.

8. Cadmium Contamination of Biota, Water and Sediment in the Vicinity of Belledune Harbour, 1980.

Scientific Contact:
S. Ray, D.W. McLeese, Fisheries & Oceans
St. Andrews, New Brunswick.

Samples of biota, water and sediments were collected May 5-16 from an area 40 km along the shore and 1 km offshore in the vicinity of the smelter. The results indicate a band of contaminated sediment which extends diagonally from Belledune Harbour to the southeast across the sampling area. Cd concentrations also declined with depth of the water column.

Maximum Cd concentrations were generally found in animals from the center of the contaminated area. Elevated Cd levels (compared to data for other areas) were found in the filter-feeding bivalves (P. magellanicus, M. edulis, M. modiolus, C. ciliatum, M. mercenaria), predators upon bivalves (B. undatum, A. occidentalis), the herbivorous gastropod Littorina sp., the filter-feeding crustacean (B. balanoides), and the carnivore/scavenger (C. irroratus). Only macrophytic algae, polychaetes and flatfish species contained Cd levels near reported "baseline" concentrations.

Publication:
Ray, R., D.W. McLeese, 1980. Distribution of cadmium in marine biota in the vicinity of Belledune. In: Cadmium Pollution of Belledune Harbour, New Brunswick, Canada. J.F. Uthe and V. Zitko (editors). Can. Tech. Report, Fish Aquat. Sci. No. 963.

9. Heavy Metals in the Belledune Harbour Area.

Scientific Contact:
D. Loring, Marine Ecology Laboratory
Fisheries and Oceans Canada
Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

A survey of heavy metals and hydrology in the vicinity of Belledune Harbour, New Brunswick, was carried out following the detection of elevated Cd levels in lobsters in this area. Twenty-two grab samples and 6 water samples were collected within Belledune Harbour, and 13 grab and 12 water samples were obtained from coastal zone transects to the west and east of Belledune Harbour. Results of the heavy metal analyses revealed that Belledune Harbour was heavily contaminated with Cd and Zn, while levels outside the Harbour declined rapidly to background values. Cadmium-rich particles had a bimodal distribution indicating that fine and coarse (5-8 m) particles are important agents of Cd transport. Most of the Cd-contaminated particles remain trapped at the western end of the Harbour. Residual coastal circulation is thought the most prominent mechanism of particle and aqueous transport. The potential of storm events to produce considerable redistribution of the contaminated sediments warrants further investigation.

Publication:

Loring, D.H., J.M. Bewers, G. Seibert and K. Kranck, 1980. A preliminary survey of circulation and heavy metal contamination in Belledune Harbour and adjacent areas. In: Cadmium Pollution of Belledune Harbour, New Brunswick, Canada. J.F. Uthe and V. Zitko (editors). Can. Tech. Report, Fish. Aquat. Sci. No. 963: 35-48.

10. Point Lepreau Environmental Monitoring.

Scientific Contact:
M. Bewers, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada
Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Techniques for laboratory analysis of environmental levels of radioactivity were further developed and applied to samples of water, suspended particulate matter and sediment samples collected from the western Bay of Fundy in May 1979. Tritium, Cs-137 and Sr-90 levels were typical of those reported for near-shore marine environments. Net deposition occurs here with sedimentation rates of the order of 1/cm/ annum. Activities of artifically produced radionuclides, such as Co-60 and Zn-65, which will be released in small but measurable quantities from the Point Lepreau CANDU reactor, are presently below analytical detection limits.

In 1979/80, large volumes of water were collected for radionuclide analysis using modified ion-exchange techniques for the concentration of Cs-137. Hydrographic, nutrient and trace metal data coverage was extended from 10 stations to 35 in 1979 and to 48 in 1980 in order to characterize the extent and effect of the freshwater plume from the Saint John River. Box and gravity cores were collected during each cruise in order to estimate sediment accumulation and mixing rates in the western basin of the Bay of Fundy.

Other studies carried out through contract, or with the assistance of other agencies, include:

1) The collection of biological samples from Point Lepreau for radioactivity analysis.

2) An ecological baseline survey of the nearshore benthic community near Point Lepreau.

3) A re-examination of the benthic community in Coleson Cove in order to determine any effects associated with thermal discharges.

4) An assessment of the sampling requirements for the freshwater and land environments.

5) A collection program for several species of winter birds for the subsequent radionuclide analyses of critical organs.

The Atlantic Oceanographic Laboratory has also conducted a drifter survey using both surface and bottom drifters in order to elucidate circulation patterns relevant to the transport of emitted nucleotides. Atmospheric sampling stations have been constructed that will collect atmospheric water vapour and particulates and extract I-131 from large volume air samples.

During 1981 the sediment dynamics in the western basin will be studied. The benthic survey conducted in the vicinity of Point Lepreau in 1979 will be repeated later in 1980 in order to assess the extent of seasonal variations in this community. Atmospheric monitoring stations will also be deployed around Point Lepreau to measure pre-operational baseline concentrations of Cs-137 and H-3 in atmospheric particulates and water vapour, respectively.

Publication:

Bishop, F.J., K. Ellis, J.N. Smith and J.M. Bewers, 1980. Preoperational environment monitoring report for the Point Lepreau, N.B., nuclear generating station BI-R-80-1.

11. Pesticide Content of Sediments and Bivalves from Two P.E.I. Estuaries Draining Agricultural Areas.

Scientific Contact:
W. Ernst, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

Endrin residues in sediments of the Dunk River were greater than those found in major agricultural drainage sediments of central Canada. High erosion rates and subsequent loss of sediment bound pesticides may be responsible. Endrin was not detected in Mill River sediments. Bivalve endrin levels were well below the maximum F.A.O. limit.

MCPA residues in Dunk River and Mill River sediments were similar to those of highly agricultural areas of central Canada. Residue levels did not vary significantly during the summer, despite a half life of several days reported from studies done in the southern U.S. and its primary use as a pre-emergent or early season treatment on grain crops.

In 1982, information on type, use, and disposal of biocides in agriculture and industry in P.E.I. will be assembled. Potential problems and environmentally significant hazards will be identified.

Aquatic systems which drain intensively cultivated land will be sampled periodically during the growing season. The Dunk River in P.E.I. has been tentatively identified for the 1981 survey. A N.B. location has not yet been determined. Prospective chemicals for 81/82 include chlordane, atrazine and diquat.

In addition, sampling of aquatic ecosystem components for residues from forestry herbicide applications will take place. Sampling sites will be in areas subjected to known spray application techniques and formulations. Approximtely 35 samples will be analyzed for 2,4-D, 2,4,5-T or glyphosphate.

Publication:

Ernst, W., G. Pelly and G. Julien, 1980. An examination of two P.E.I. estuaries to determine the extent of contamination by several commonly used pesticides - endrin, MCPA and maneb. In-house EPS report.

12. Ocean Dumping Site Monitoring During 1980.

Scientific Contacts:
G.A. Packman, K.L. Tay, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia

As part of the activities under the ODCA, dredge and dump sites are monitored in an effort to assess the levels of contaminants and environmental disturbance present in these areas. The following sites in New Brunswick were investigated in 1980: Dalhousie Harbour, Restigouche Co.; Heron Island Dump Site, Chaleur Bay; Belledune Harbour, Gloucester Co.; Pointe Verte, Gloucester Co.; Petit Rocher, Gloucester Co.; and Escuminac, Northumberland Co. Sediment and biota samples were collected from each site and analyzed for cadmium content. Bioassays were conducted in several cases and test organisms were found to uptake significant levels of Cd from sediments at Belledune.

The following sites in Nova Scotia were also investigated in 1980: Newellton, Shelburne Co.; West Green Harbour, Shelburne Co.; Canso, Guysborough Co.; Petit-de-Grat, Richmond Co.; and Bay St. Lawrence, Victoria Co. Sediment and/or biota samples were collected from each site and analyzed for cadmium. PCBs were determined in sediments from Canso and Petit-de-Grat, Nova Scotia.

One site was sampled in P.E.I. at Rustico Harbour (inner), Queens Co., for the cadmium content of the sediments.

13. Ecological Responses to and Chemical Fate of Insecticides Used in the N.B. Forest Spray Program - EMOFICO

Scientific Contact:
Committee for Environmental Monitoring of Forest Insect Control Operations (EMOFICO)
University of New Brunswick, Fredericton, New Brunswick.

Summary reports of the environmental monitoring of the 1978 and 1979 aerial spray operation over New Brunswick were compiled. They include insecticide ecology in fir-spruce forests and associated ecosystems; studies on songbirds and squirrels, predaceous and parasitic insects, pollinators, freshwater fauna, toxicology and insecticide transport, persistence and environmental distribution.

Long-term ecological damage was not detected, although the margin of safety for breeding success in songbirds is narrow. Fenitrothion depresses wild bee abundance, sometimes resulting in marked reduction in pollination of some forest plants. A survey of blueberry fields however, showed that insecticide drift was too light to pose a hazard to the industry. Although broad spectrum mortality of non-target forest arthropods also results from insecticide treatment, disruption of pest and predator dynamics was not evident. Freshwater effects were variable for fenitrothion and slight for aminocarb, but did not apparently include reduced salmonid abundance or growth. Nonylphenol, shown to be toxic to salmon, trout and some aquatic invertebrates, was found at low levels in the field. Extensive long-range drift of insecticides was reported with mostly trace amounts found shortly after the spray operation in marine shellfish.

Publication:

EMOFICO, 1980. Environmental surveillance in New Brunswick, 1978-79 effects of spray operations for forest protection against Spruce Budworm, I.W. Varty, Chairman.

14. Long Range Transport of Atmospheric Pollutants: Precipitation and Aerosol Sulphate Sampling.

Scientific Contact:
J. Kozak, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

Event precipitation samples were collected at two sites in the Halifax area and one site in the Charlottetown area. A total of 160 precipitation samples were collected in 1980/81. Annual pH values varied between 4.2 and 4.6 in the region.

Aerosol sulphate samples were collected at one site in the Halifax area. During 1980/81, 70 samples were collected and the sulphate values varied between 0.5 $\mu g\ SO_4^{=}/m^3$ to 17 $\mu g\ SO_4^{=}/m^3$.

15. Long Range Transport of Atmospheric Pollutants: Calibrated Basin Study Program.

Scientific Contact:
J. Kerekes, Canadian Wildlife Service
Environment Canada, Halifax, Nova Scotia.

During 1980 more research was undertaken on water quality characteristics and biological productivity at three study lakes in Kejimkujik National Park. In conjunction with other E.C. research programs, those studies comprise the Calibrated Basin Study Program at the Park. This ecosystem study, to characterize and quantify environmental changes resulting from atmospheric pollution, is part of a national LRTAP program involving two other basin studies.

Other water quality surveys at Kejimkujik and Terra Nova National Parks were undertaken in 1980 for comparison with the results of similar studies conducted over 10 years ago. Any changes in these sensitive aquatic systems resulting from atmospheric pollution will be identified.

Water samples, in association with aerial and ground surveys of waterfowl populations, were collected in southern Labrador in 1980. Preliminary data provide a crude evaluation of the productivity of the aquatic systems in the region, with which waterfowl distribution and population data may be correlated. In succeeding years the distribution and productivity of waterfowl will be investigated, and the potential effects of continuing atmospheric pollution on regional waterfowl productivity assessed.

16. Monitoring of Precipitation Chemistry.

Scientific Contact:
D.B. Sergeant, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Precipitation monitoring of snow and rain occurred in 1979/80 as part of a one year study, which terminated in late July. Correlation analyses, computer plotting of trends and other statistics for 1978 and 1979/80 precipitation data are complete. A technical report is in preparation.

17. Chemical Composition of 16 Softwater Lakes in Nova Scotia and New Brunswick, April-August, 1979.

Scientific Contact:
J.R. Machell, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

In 9 of the 11 study lakes remote from principal SO_x emission sources, pH levels were 0.3-0.7 units below values reported during 1930-1950. Analysis of the pH record available for 6 of the lakes suggests that pH declines have been confined to the post 1950's period. No long term trend was suggested for one lake and historical data was lacking for another's comparison with 1979 data.

In 4 of the 5 lakes within 10-30 km of Halifax, pH values were 0.9-1.4 pH units below reported mid-1960's values. The historical data did not suggest a consistent trend in the remaining lake.

Lake alkalinities were in the range 32-1699 μeq/l, and in 12 of the lakes were less than 50 μeq/l. The calcite saturation index was greater than 3 in 15 lakes, and was generally in the range of 5-8.

Lakes in the pH range 4.4-4.8 exhibited elevated levels of iron (20-310 ppb), aluminum (100-210 ppb) and manganese (20-160 ppb).

In some of the lakes the effects of organic acids were apparent in pH-alkalinity and possibly pH-calcium ion relationships, but not in alkalinity-calcium ion relationships.

Publication:

Wiltshire, J.F. and J.R. Machell, 1980. A study of acidification in sixteen lakes in mainland Nova Scotia and southern New Brunswick. EPS Manuscript Report EPS-5-AR-81-4.

18. Monitoring of pH in Nova Scotia Rivers.

Scientific Contact:
W. Watt, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Water samples from 24 Nova Scotia rivers have been collected, on a monthly basis during 1980, to obtain seasonal variation in pH values.

19. A Survey of the Distribution of Stream Fish in Nova Scotia Rivers Undergoing Acidification.

Scientific Contact:
W. Watt, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Electro-fishing has been carried out on seven acid rivers and on the Gold River which was approaching the "danger point" (mean pH = 5.6). Salmon have been found only on the Gold River, which confirmed the hypothesis that salmon populations cannot exist in Nova Scotia rivers below pH 5. Trout were found in the Sable River at pH 4.7, but the population there evidently consisted only of old fish. Young-of-the-year trout were caught on one occasion in the Sable, but disappeared from that site a few weeks later. Gaspereau were caught in several rivers and were numerous at pH 6. Eels were numerous in all rivers. Perch, including juvenile specimens, were caught in several rivers as low as pH 4.5.

20. Industrial Monitoring for Compliance With Clean Air Act Regulations, 1980/81.

Scientific Contact:
J. Kozak, Air Pollution Control Division
Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

Lead Free Gasoline - In 1980, 271 lead free gasoline samples were collected from retail outlets. Of these samples, 17 were contaminated, a 6.3% violation rate. The fuel was seized on three occasions, and in almost all cases, the contaminations were corrected within 1 to 2 days. No violations under the Regulations were detected at the refineries in the Region.

Leaded Gasoline - No violations under the Regulations were detected at the refineries in the Region.

Secondary Lead Smelters - There was no stack-test carried out at Surrette Battery Ltd. in 1980. However, improvements were made to the air pollution control equipment on the lead kettles, lead oxide process and tap holes, and on the blast furnace. Several inspections were made of the facility during 1980.

The CNR brass foundry in Moncton was investigated in terms of being under the Regulation. It was decided that certain portions do fall under the Regulations and negotiations will be held with CNR in 1981.

Chloralkali-Mercury - Quarterly compliance tests were carried out at both CIL Dalhousie and Canso Chemicals Ltd. in 1980. In all cases, the mercury emissions were within the limits specified by the Regulations.

Asbestos Mining and Milling - Compliance tests were carried out at Advocate Mines in June, 1980, and all sources were found to be in compliance except the dry rock storage facility. The dry rock storage operation is a minor source, but the company was requested to make modifications to the control equipment and to carry out extensive testing in early 1981.

21. Survey of Michelin Tire and the LaHave River Near Bridgewater, Nova Scotia.

Scientific Contact:
J. Day, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

The Michelin plant discharge stream and LaHave River were sampled during August, 1980, for heavy metal concentration and hardness. Salinity, temperature, and conductivity were measured "in-situ". Water samples were taken at 2 of the 6 stations on the discharge stream for bioassays. A dye test was also conducted on the discharge effluent channel.

Results were similar to last year's survey, with the exception of the station located 100 feet above the Michelin outfall. At this site, iron and aluminum in water samples increased from 4.05 to 20.7 ppm and 1.21 to 6.4 ppm, respectively. Sediment copper and zinc also increased from 18.7 to 23 ppm for Cu, and 22.4 to 36.0 for Zn.

The results of the static bioassay showed that the effluents were not acutely lethal at 100% concentration.

22. Neutron Activation Analysis for 39 Elements in Nova Scotia Raw and Washed Coals.

Scientific Contact:
M. R. Sandeman, Chemistry Department, Dalhousie University
Halifax, Nova Scotia.

The trace element content of Nova Scotia coals was found to be comparable to bituminous coals of the U.S. and Belgium, although higher in some elements, i.e., Mg and Hg. The cleaning process at DEVCO's coal preparation plant (heavy fraction cycling of crushed coal, followed by centrifugal drying of products) removes rock and high S particles, and reduces the levels of most elements, with the possible exception of Br, Cl, I and Se in the metallurgical coal product. Raw coal and thermal belt coal, however, are high in S and ash.

Publication:

Sandeman, M.R., 1979. Thermal and epithermal neutron activation analysis of Nova Scotia raw and washed coals. M.Sc. Thesis, Dalhousie University.

23. Bioavailability of Elements in Sewage Sludges.

Scientific Contact:
A. Chatt, Trace Analysis Research Centre, Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

Thermal INAA (Instrumental Neutron Activation Analysis) Methods have been developed for determining the elemental content of sewage sludge. INAA was used to evaluate metal determination by flame atomic absorption. Dry ashing and nitric acid extraction appear to be less efficient in terms of metal recovery than wet ashing in acid digestion bombs.

24. Elemental Composition of Coal and Coal-Derived Products

Scientific Contact:
A. Chatt, T.A.R.C., Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

Thermal and epithermal INAA (Instrumental Neutron Activation Analysis) methods have been developed for the simultaneous determinations of 40 elements in Nova Scotia bituminous coals. INAA methods have been used to study the behaviour of trace elements in a coal preparation plant, and presently are being extended to include studies on coal liquification and gasification processes.

Scrubber and fly ash, the two main solid waste products of coal mine disposal, are being studied as to their potential disposal and use as artificial reefs. The composition of stabilized coal-waste blocks, and leachability of elements from these blocks are being investigated using INAA.

25. Baseline Data on Trace Element Emissions From An Oil-Fired Power Plant.

Scientific Contact:
A. Chatt, T.A.R.C., Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

Conventional, pseudocyclic and cyclic INAA methods, using thermal and epithermal neutrons have been developed to measure concentrations of up to 37 elements in feeding oil, bottom ash, fly ash and other oil-waste products. Size and density-fractioned portions are being analyzed to obtain information on formation and association of particles in ash. Atmospheric particulate materials collected by high volume and size-fractioning samplers are being studied to estimate the particulate emissions of an oil-fired power plant. Several leaching experiments are being carried out to study the bioavailability of toxic elements from power plant waste products.

26. Organic Matter in the Surficial Sediments of The Miramichi Estuary.

Scientific Contact:
M.A. Rashid, Atlantic Geoscience Center
Energy, Mines & Resources, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Distribution, composition and characteristics of organic matter in the surficial sediments were studied as part of a multidisciplinary environmental study of the Miramichi estuarine system. Organic carbon distribution generally corresponded to the distribution of fine grained sediment, although higher concentrations occurred in sediments of the river channel than the bay portion of the estuary. These differences in concentrations, and the generally high organic content of the sediments, are the results of the discharge of pulp mill effluent into the upper reaches of the estuary. Marine organic material is restricted to the sediments near the mouth of the estuary. Dispersal of organic matter is largely through transport in the upper freshwater-effluent layer, and settling through the water column when transport energies are reduced.

Publication:
Rashid, M.A. and G.E. Reinson, 1979. Estuarine and Coastal Marine Science. 8:23-36.

27. Trace Metals in Sediments of the Miramichi Estuary.

Scientific Contact:
R. Fitzgerald, Atlantic Oceanographic Laboratory
Fisheries & Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Total metals (including Fe, Na, K, Ca, Mg, Si, Al, Zn, Cu, Mn, Ni, Co, Cr, Li, Ti and Pb), weak acid leachable metals, oxidizable and organically-bound metals, and reducible metals, were determined on the fine and clay size sediment fractions from the Miramichi estuary. The fine fraction had an inorganic association with the river sediments contributing total Mn, Pb, Zn and Cu (probably related to mining activities) and an association of organic input into the estuary, which contributed Fe, Zn and Cu in leachable form (probably orginating in pulp and paper effluent and municipal sewage). Much of the coarse fraction organic input into the estuary was wood-derived. Miramichi bottom sediments had higher concentrations of total and weak acid leachable Zn and organic carbon, compared with other sediments in eastern Canada. Concentrations of all trace metals were considerably less in the coarse fraction compared to the fine fraction.

Publication:
Willey, J.D. and R.A. Fitzgerald, 1980. Trace metal geochemistry in sediments from the Miramichi Estuary, New Brunswick. Can. J. Earth Sci. Vol. 17, 1980, 254-265.

28. Particulate Matter in the Bay of Fundy and Saint John Harbour.

Scientific Contact:
K. Kranck, Atlantic Oceanographic Laboratory
Fisheries & Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The dynamic processes controlling the distribution of particulate matter in a very active environment, the Bay of Fundy, were investigated. Work has concentrated on the Saint John area in order to determine the relative roles of natural sedimentation and disposal of dumped dredge spoils in harbour siltation. Results will also have application to sedimentation problems resulting from tidal power development.

Summer temperatures and high concentrations of organic matter were associated with rapid flocculation and settling, and rapid resuspension by near-bottom turbulence. Winter conditions were characterized by slower settling rates and less resuspension, presumably due to the relative scarcity of large fragile organic-inorganic aggregates. Muddy sediment was being deposited in areas with high suspended sediment concentrations, due to the cohesive nature of mud. This resulted in high sedimentation rates towards the head of the Bay of Fundy, despite the relatively high current velocities. Sand deposition, in contrast, was closely controlled by current energy. Trace metal concentrations showed the integrated deposition effect of dredge spoils from the dump site and other sources.

Work will be described in 2 or 3 publications during the next 2 years.

29. Distribution, Abundance, and Recruitment of Lobster Larvae in St. Georges Bay and the Possible Effects of the Canso Causeway on Chedabucto Bay Lobster Fishery.

Scientific Contact:
G.C.H. Harding, Marine Ecology Laboratory
Fisheries & Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The possible effects of the Canso Causeway on the Chedabucto Bay lobster fishery is being re-evaluated from 1978 data. Preliminary results indicated that the importance of St. Georges Bay as a source of larvae for Chedabucto Bay, prior to construction of the causeway, may have been underestimated by an order of magnitude.

A report will be prepared in 1981.

30. An Investigation of the Oxygen Balance in L'Etang Harbour, New Brunswick.

Scientific Contact:
D.D. Kristmanson, Department of Chemical Engineering
University of New Brunswick, Fredericton, New Brunswick.

L'Etang Harbour, which receives the wastes from a neutral sulfite pulp mill near St. George, New Brunswick, was subject to considerable dissolved oxygen deficits, particularly in late summer. The various sources and sinks of oxygen are being examined with the view to development of a water quality model. This work is an extension of the work begun by Wildish, Poole and Kristmanson (1980, "Pulp Mill Pollution in L'Etang Estuary: A Case History and Cleanup Alternatives", Fisheries and Marine Service Tech. Rep. No. 884, Fisheries and Environment Canada, 1979).

Physical conditions in the upper part of the lower L'Etang during 1980 were determined. Data will be used to produce an assimilation model of the ecosystem for determining options for mitigating the anaerobic conditions caused by the pulp mill's effluent.

31. Physical-Chemical Controls of Particulate Heavy Metals in a Turbid Tidal Estuary.

Scientific Contact:
D.H. Loring, Marine Ecology Laboratory
Fisheries & Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The behaviour of heavy metals associated with SPM in an area (Tamar Estuary) having (1) high metallic inputs, (2) a well defined turbidity maximum and (3) for which diurnal physical-chemical parameters (i.e., salinity, temperature, pH, O_2 saturation, POM, and chlorphyll) are well known, was studied. Results can be applied to turbid tidal estuaries of the Fundy region. Preliminary data (winter and spring data sets) indicated that salinity was a major control on the variance of Ca and Mg correlations by ion exchange reactions and carbonate formation. Particulate matter concentration controlled the variance of such elements as Cu and Mn. Changes resulting from biological growth and decay played an important part in the levels of Mn, Fe, Cd, Cu and Zn in the SPM. Verification on a seasonal basis of the initial results is planned. This will be integrated with dissolved metal levels and other parameters to provide data for modelling the heavy metal fluxes and residence times. The response of metals such as Cd to changes in physical-chemical conditions in the Tamar Estuary, as well as probable effects on particulate metal concentration in areas such as the Bay of Fundy (where interference with chemical analysis is greater) will be determined.

32. Miramichi Environmental Impact Assessment in Relation to Proposed Dredging Program.

Scientific Contact:
J. Uthe, Fisheries & Oceans Canada
Halifax, Nova Scotia

Lobster samples were obtained from the four Miramichi Estuary sites sampled in 1979. Oysters were also taken. The 1979 lobster digestive gland samples were analyzed for Cd, Hg, Se, and Cu and mean values of 7.85, 0.05, 0.57 and 13.8 μg/g wet weight were obtained. Tail muscle Hg levels averaged 0.145 μg/g wet weight.

Lobster samples were fixed for histopathological examination.

The delay in the proposed dredging program has allowed time to develop a two year data baseline from which to judge future environmental effects of dredging and dredge spoil disposal.

33. Chedabucto Bay Environmental Impact Assessment.

Scientific Contact:
J. Uthe, Fisheries & Oceans Canada
Halifax, Nova Scotia.

Water samples (for salinity determinations), sediments and blue mussels were collected from Chedabucto Bay in 1980. The mussels were fixed for histopathological examination. PCB concentrations in the sediments ranged from 1-125 ng/g.

34. Gonyaulax Monitoring in Southwestern Bay of Fundy.

Scientific Contact:
A. White, Fisheries & Oceans Canada
St. Andrews, New Brunswick.

A weekly sampling program has been in progress since May, 1980, at two stations in the southwestern Bay of Fundy in order to:

1) Monitor the number of Gonyaulax and examine the population dynamics of blooms, especially with regard to vertical distribution.

2) Collect biological and oceanographic data in conjunction with Gonyaulax blooms, including temperature, salinity, light, nutrients, other phytoplankton and Gonyaulax cysts.

3) Collect mud samples for Gonyaulax cyst analysis.

4) Collect water samples for water quality growth studies.

Abnormally low spring temperatures lead to a delayed diatom bloom, with species composition differing from the usual. A late May to early June "false start" of a Gonyaulax bloom occurred; however, as observed in past years, at the end of June the numbers greatly decreased.

A "Red Water" occurrence in the Bay of Fundy (sighted on August 17, 1980), was confirmed to be caused by Gonyaulax. Dead herring were reported off St. Andrews August 15-17, 1980.

A study of the influence of water quality on Gonyaulax growth was conducted. Water samples were stored for several months, enriched with inorganic nutrients, related trace metals, vitamins and soil extract and innoculated with Gonyaulax. The growth response of Gonyaulax in culture differed, depending on the season in which the seawater was collected and how long it was stored.

The distribution and abundance of overwintering Gonyaulax cysts in Bay of Fundy sediments are being investigated. Because the cysts are, themselves toxic and because they are the initiators of subsequent blooms, they represent an important aspect of the problems of toxification of finfish and shellfish.

3. ECOTOXICOLOGY

3.1 Bioavailability, Behaviour of Pollutants

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3.2 Bioaccumulation, Metabolism of Pollutants

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49. Adenylate Energy Charge and ATP Use Activity in Lobster from Belledune Harbour - K. Haya (p. 64).

50. Adenylate Energy Charge (AEC) as an Indicator of Sublethal Xenobiotic Effects in Winter Flounder and Crab - K. Haya (p. 66).

51. Metallothionein Induction as a Sublethal Biological Indicator of Metal Pollution - S. Ray (p. 67).

52. Histology of the Hepatopancreas, Gill and Green Gland Tissues of Cadmium Contaminated Lobsters from Belledune Harbour - P. Odense (p. 68).

53. Di-2-ethylhexyl Phthalate (DEHP) Effects on Steroid Hormones in Cod (*Gadus morhua*) - H.C. Freeman (p. 69).

54. Di-2-ethylhexyl phthalate (DEHP) Effects on Androgens in Brook Trout (*Salvelinus fontinalis*) - H.C. Freeman (p. 70).

55. Metabolism and Toxicity of Petroleum Hydrocarbons in the Marine Food Chain - J.H. Vandermeulen (p. 71).

56. Mutagenic Compounds in the Marine Environment - J. Payne (p. 72).

57. Effects of Spruce Budworm Spray Program on Migratory Forest Birds in New Brunswick - P.A. Pearce (p. 73).

58. Sensitivity of Marine Fish to *Gonyaulax* Toxins - A.W. White (p. 74).

59. Physiological Responses of Salmon (*Salmo salar*) and Trout (*S. gairdneri*) to reduced pH - P.G. Daye (p. 75).

60. Effects of pH on Salmon Egg Hatching Enzyme (Chorionase) - K. Haya (p. 77).

61. Effect of Contaminants on the Filtration Rate of Bivalve Mollusks - D.W. McLeese (p. 78).

62. Lethality of Endosulfan to *Crangon* Shrimp in the Presence of Varying Amounts of Sediment - S. Ray (p. 79).

35. Potential Bioavailability of Heavy Metals in Suspended Particulate Matter (SPM).

Scientific Contact:
D.H. Loring, Marine Ecology Laboratory, Fisheries and Oceans Canada
Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

As SPM from the Bay of Fundy contains high concentrations of Cd (up to 200 ppm) and Zn (approximately 900 ppm), new techniques were developed to estimate the potential bioavailability of metals in the small quantities collected. Initial results indicate that in SPM derived from mineralized land areas, 5-92% of the Cu, 80-92% of the total Zn, 10-40% of the total Fe and 60-80% of the Mn is potentially available to the biota. The accuracy and precision of this technique and time required for extraction of the soluble metal fractions from SPM are being improved.

Publication:

Loring, D.H. In Press. Potential bio-availability of metals in eastern Canadian estuarine and coastal sediments, ICES Rapports et Proces-Verbank, Proc. of Toxicol. Workshop on Sediments and Pollutant Exchange.

36. Distribution and Fate of Petroleum Hydrocarbons in Marine Environments.

Scientific Contact:
J.H. Vandermeulen, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Studies to date have focused on the fate of petroleum hydrocarbons in the water column and sediments, and the resulting bioavailability of dissolved and sediment-bound hydrocarbons to various levels of the marine food chain. During the last year, work began on the development of a model of oil interaction with a range of bottom types in order to describe the processes of oil stranding and re-entry into the marine environment. The recovery and self-cleaning potential of a heavily oiled saltmarsh (Ile Grande, France), a high energy rocky shore (Ti Soczen) and low energy mudflat (Aber Benoil, France) were studied. In addition, the fate of buried oil in sandy beaches, with respect to its migration and distribution within the beach structure and underlying water table was described. During the next two years, a model of self-cleaning and oil persistence in a broad range of low energy inshore marine environments will be developed.

Publications:

Vandermeulen, J.H., D.E. Buckley, E.M. Levy, B.F.N. Long, P. McLaren and P.G. Wells, 1979. Sediment penetration of AMOCO CADIZ oil, potential for future release, and toxicity. Marine Pollution Bulletin, 10, 222-227.

Long, B.F.N. and J.H. Vandermeulen, 1979. Impact of clean-up efforts on an oiled saltmarsh (Ile Grande) in North Brittany, France. Spill Technology Newsletter, Vol. 4:218.

Long, B.F.N., J.H. Vandermeulen and D.E. Buckley, 1980. Les processus de la migration du petrole échoué dans les estrans sableux: Contamiation des nappes phréatiques. Publ. Sci. Tech. CNEXO.

Traxler, R.W. and J.H. Vandermeulen, 1980. Hydrocarbon-utilizing microbial potential in marsh, mudflat and sandy sediments from North Brittany. Publ. Sci. Tech. CNEXO.

Vandermeulen, J.H., B.F.N. Long and T.P. Ahern, 1980. Bioavailability of stranded AMOCO CADIZ oil as a function of environmental self-cleaning: April 1978-January 1979. Publ. Sci. Tech. CNEXO.

37. Speciation of Methylene Blue (as a Model Herbicide), Paraquat and Diquat in a Model System and Effects on Algae.

Scientific Contact:
R.D. Guy, Chemistry Department, Dalhousie University
Halifax, Nova Scotia.

Bentonite (clay), humic acid (HA), polystyrene sulphuric acid (PSSA), methylene blue (MB) and paraquat comprised the model system. Results indicate that a combination of dialysis separation, variation of ionic strength and spectrophotometric analysis could be used to determine free paraquat and bound paraquat susceptible to changes in environmental levels of pH and ionic strength. Clay particles were found to control the organo-cation concentration at levels of paraquat that do not exceed the clay's cation exchange capacity. Above this level, humic acid will bind cations. As this additive humic acid-paraquat interaction is susceptible to changes in ionic strength, significant amounts of herbicide may be released in estuaries.

A model study using tryptophan as a target molecule for attack by O_2 indicated that binding of MB by clay, humic acid and PSSA inhibited production of a singlet oxygen and reduced the toxicity of the dye. The binding of MB by humic acid was found to increase the persistence of the dye in solution, however, resulting in prolonged toxicity of the dye to algae.

Publications:

R.D. Guy and D.R. Narine: A model system for the investigation of herbicide speciation. In: "Hydrocarbons in the Aquatic Environment" (ed.), B.K. Afghan and D. Mackay. Plenum Press, New York, pp 417-434 (1980).

R.D. Guy, D.R. Narine and S.M. DeSilva: Organo-cation speciation I. A comparison of the interactions of methylene blue and paraquat with bentonite and humic acid, Can. J. Chem., 58, 547 (1980).

R.D. Guy and D.R. Narine: Organo-cation speciation II. Methylene blue photosensitization as a model for speciation and toxicity of herbicides, Can. J. Chem., 58, 555 (1980).

R.D. Guy, D.R. Narine and S.M. DeSilva: Dye-colloid interactions as a model for pollutant persistence in the aquatic environment. Environ. Sci. Technol. (in press).

38. Algal Growth and Metal Speciation in Chelating Ligand Solutions.

Scientific Contact:
R.D. Guy, Chemistry Department, Dalhousie University
Halifax, Nova Scotia.

A comparison of algal growth and copper speciation in chelating ligand solution was used to illustrate the problems in relating binding capacity and metal toxicity.

A comparison of the metal ion (Cu^{2+}, Hg^{2+}, and Cd^{2+}) binding capacity of humic and clay colloids and the ability of the water system to support algal growth is in progress.

Publication:

R.D. Guy and A.R. Kean: Algae as a chemical speciation monitor 1. A comparison for algal growth and computer calculated speciation. Water Research (in press).

39. Dynamics of Arsenic in Marine Phytoplankton.

Scientific Contact:
R. F. Addison, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

As (as arsenate, As IV), was incorporated rapidly into the lipids of marine phytoplankton, and was associated with 3 major fractions. As incorporation into plankton, and the processes involved in interactions between other metalloids and plankton will be studied further.

40. Bioavailability and Toxicity of Cd, Zn and Pb to Marine Invertebrates.

Scientific Contact:
S. Ray, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Polarographic studies on free and bound Cd indicated that all Cd in Macoma was in bound form.

Preliminary work began on Cd and Pb uptake through food chains by lobsters. Lobster food containing 25 ppm Cd and 2 ppm Pb was prepared by mixing hepatopancreas of lobsters from Belledune with flounder muscle. The contaminated food was fed at a rate of 5% of body weight/week (fed on alternate days) to lobsters held individually in a flow-through system. Metal distribution in seven organs was determined after 15, 30 and 45 days. The remaining lobsters were separated into two groups for depuration studies.

Shrimp exposed to both Cd (40 μg Cd/L) and Zn (70 μg Zn/L) had different rates of Cd uptake, compared to those exposed to Cd alone. Zn tissue levels were not affected by Cd exposure; however, Cd uptake in the hepatopancreas almost doubled while decreasing in the carcass. This suggests increased induction of metallothionein in the hepatopancreas, resulting in the faster redistribution of Cd to the hepatopancreas.

Shrimp were exposed to Cd (40 ppb) in the presence of Zn (10 ppb instead of 70) in a continuation of the latter study. This work is in progress.

Publication:

S. Ray, D.W. McLeese, B.A. Waiwood and D. Pezzack, 1980. The disposition of Cadmium and Zinc in Pandalus montagui. Arch. Environ. Contam. Toxicol.

41. Bioaccumulation of Metals in *Macoma* and *Nereis*.

Scientific Contact:
S. Ray, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Previous studies included Cd accumulation in *Nereis virens* exposed to Cd spiked sediment (1-4 ppm Cd) and sea water at several levels (0.03-9.2 ppm). Equilibrium concentrations were not reached with a 24 day exposure; smaller worms accumulated higher amounts/unit weight than larger worms and excretion rates were negligible. Cd concentration in the overlying water was related to sediment Cd levels. Comparison of the uptake from sediment and water suggests that Cd accumulation by the worms is mainly from Cd released to the water by sediments.

During 1980, *Nereis virens* and *Macoma* were exposed to several levels of Pb in sea water, and at different salinities (in progress).

Publication:
Ray, S., D. McLeese and D. Pezzack, 1980. Accumulation of cadmium by *Nereis virens*. Arch. Environ. Contam. Toxicol. 9:1-8.

42. Uptake and Clearance of p,p'-DDT by Zooplankters Through Feeding and from the Aqueous phase (*Thysanoessa roschii* and *Calanus finmarchicus*).

Scientific Contact:
G.C.H. Harding, Marine Ecology Laboratory
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

An earlier model of DDT flux between seawater and planktonic crustacea was expanded to include uptake from gut surfaces. At lower cell density, *Calanus* retained 60-70% of the DDT ingested, but under "bloom" conditions *Calanus* appeared to retain as little as 10%.

Publications:

G.C.H. Harding and W.P. Vass, 1979. Uptake from seawater and clearance of p^1p'-DDT by marine planktonic crustacea. Vol. 36:247-254.

G.C.H. Harding, W.P. Vass and K.F. Drinkwater, 1980. Importance of feeding in the accumulation of an organochlorine (p,p'-DDT) by the marine planktonic copepod *Calanus finmarchicus*. Can. J. Fish. Aquat. Sci. (in press).

43. Seasonal Cycle of Organochlorine Content in Size-Fractioned Zooplankters in St. Georges Bay.

Scientific Contact:
G.C.H. Harding, Marine Ecology Laboratory
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Feeding experiments with labeled PCBs are planned to determine assimilation efficiencies with copepods. PCB levels in copepod populations will be predicted on the basis of a model developed for p,p'-DDT and compared with measured levels in St. Georges Bay.

44. Uptake of PCBs from Sediment by *Nereis virens* and *Crangon septemspinosa*.

Scientific Contact:
D.W. McLeese, Fisheries and Environmental Sciences
Fisheries and Oceans Canada
St. Andrews Biological Station, New Brunswick.

Accumulation was directly related to PCB concentration (0.03-0.17 mg/kg) in the sediment, and exposure time (32 days) and inversely related to worm size. Equilibrium concentrations were not attained, and there was no obvious excretion of PCBs. Concentration factors ranged from 10.8 (small worms) to 3.8 (large worms) in *Nereis* and 3.5 (0.1 g shrimp) - 1.9 (2.9 g shrimp) for *Crangon septemspinosa*.

Publication:
McLeese, D.W., C.D. Metcalfe and D.S. Pezzack, 1980. Uptake of PCBs from sediment by *Nereis virens* and *Crangon septemspinosa*. Arch. Environ. Contam. Toxicol. 9:507-518.

45. PAH Uptake and Depuration in Lobsters Under Winter Impoundment Conditions.

Scientific Contact:
J.F. Uthe, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Lobsters were sampled (n=10) in winter from a pound from which lobsters with high PAH levels had previously been found. Digestive glands and tail muscles were prepared and analyzed for 11 common non-alkylated PAHs. Lobsters were transferred to an uncontaminated holding area and sampled at 1, 3 and 5 weeks. The study was repeated during the summer to provide comparative data at a higher temperature.

PAH tissue levels generally increased during 3-month impoundment periods. Digestive gland levels averaged 20-50 times their corresponding level in tail muscle. Benzo(a)pyrene levels in digestive gland ranged from 29-329 times the tail muscle level. PAH levels in the digestive gland had decreased one week after transfer to the "clean" area, while tail muscle values increased substantially. Tissue levels then dropped, reaching initial experimental levels after 3 weeks of depuration. The ratio of PAH in digestive gland to tail muscle increased during depuration.

Analysis of individual digestive glands from lobsters showed a wide range in individual PAH values.

After the 3 week depuration period, levels of benzo(a)pyrene in the digestive gland still exceeded the 1 μg/kg benzo(a)pyrene level allowed in smoked meat products in the Federal Republic of Germany.

Preliminary results from the summer experiment are similar to those obtained in winter.

46. Bioaccumulation of Chlorobiphenyls and Endrin from Food by Lobsters.

Scientific Contact:
D.W. McLeese, Fisheries and Environmental Sciences
Fisheries and Oceans Canada
St. Andrews Biological Station, New Brunswick.

Maximum concentration factors for lobster hepatopancreas were 5.1 and 7.3 for the chlorobiphenyls TPCB and HPCB at the low dietary level (4.0 and 4.9 mg/kg wet weight) and 1.0 and 2.9 respectively at the high dietary level (6.0 and 5.5 mg/kg wet weight). Endrin reached a maximum concentration of 1.95 mg/kg wet weight (concentration factor = 0.41) in the hepatopancreas. Chlorobiphenyls and endrin accumulated to a lesser degree in the tail and claw muscle, indicating that gross contamination of muscle tissue is unlikely.

Publication:
D.W. McLeese, C.D. Metcalfe and D.S. Pezzack, 1980. Bioaccumulation of chlorobiphenyls and endrin from food by lobsters (*Homarus americanus*). Bull. Envir. Contam. Toxicol. 25:161-168.

47. Sub-lethal Contamination and Effects.

Scientific Contact:
R.F. Addison, Marine Ecology Laboratory
Fisheries and Oceans Canada
Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Hepatic mixed function oxidase (MFO) systems in fish and the sublethal effects of various PCB replacements on trout and cod were studied.

Widely different responses of the hepatic MFO enzyme system were observed when fish were exposed by feeding to several representative pollutants at a sublethal level.

Cytochrome P-448 inducers (e.g., PCBs) produced measurable induction of the fish MFO system, while cytochrome P-450 inducers (p,p'-DDT, p,p'-DDE) produced no effects.

A PCB replacement fluid C 4, a mixture of butylated monochlorodiphenyl ethers, had little effect on any components of the MFO system except cytochrome P-450 of trout.

Aroclor 1254 (PCB) induced hepatic MFO activity in cod, while the less chlorinated 1016 did not. Three PCB replacements, designated as environmental contaminants in Japan but proposed for use in New Brunswick, also induced MFO activity in trout.

Future studies will include:

1) Sublethal effects of contaminants with emphasis on PCB replacements.

2) Laboratory studies of MFO induction will be extended to the field, by studying MFO activities in marine biota exposed to ambient levels of contaminants.

Publications:

Addison, R.F., M.E. Zinck, D.E. Willis, and D.C. Darrow, 1979. Induction of hepatic mixed function oxidase in trout by polychlorinated biphenyls and butylated monochlorodiphenyl ethers. Toxicol. Appl. Pharmacol. 49:245-248.

Willis, D.E., M.E. Zinck, D.C. Darrow and R.F. Addison, 1980. Induction of mixed function oxidase enzymes in fish by halogenated and aromatic hydrocarbons. From "Hydrocarbons and Halogenated Hydrocarbons in the Aquatic Environment. Editors B.K. Afghan and D. Mackay. Plenum Publishing Corp.

48. Physiological Effects of Crude Oil Exposure in Cunner (*Tautogolabrus adspersus*).

Scientific Contact:
J.W. Kiceniuk, Research and Resource Services
Fisheries and Oceans Canada
St. John's, Newfoundland.

Cunner exposed to crude oil for 6 months, in a previous experiment, exhibited smaller testes, reduced plasma Cl^- and Cu^{++} concentrations and increased eye lense diameters, compared to controls.

Cunner were continuously exposed to a surface slick of Venezuelan crude oil for 2 weeks in January. Results indicated that short term oil exposure can result in physiological changes, i.e., decreased spleen weight, increased gall bladder weight and increased hematocrits in oil exposed cunner.

Publications:

Kiceniuk, J.W., G.L. Fletcher and R. Misra, 1979. Determination of effects of two-week crude oil exposure on physiological and morphometric variables of a Marine Fish.

Fletcher, G.L., J.W. Kiceniuk, M.J. Kind and J.F. Payne, 1979. Reduction of blood plasma copper concentrations in a marine fish following a six month exposure to crude oil. Bull. Environ. Contam. and Toxicol. 22:548-551.

49. Adenylate Energy Charge (AEC) and ATP Use Activity in Lobster From Belledune Harbour.

Scientific Contact:
K. Haya, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Cadmium contaminated lobsters from Belledune and control lobsters from Stonehaven, New Brunswick, were collected during May, 1980. Hepatopancreas, tail muscle and gill tissue were analyzed for ATP-ase activity and Cd content.

Belledune lobsters had either significantly elevated Cd levels (n=17, p=.001) or levels similar to the uncontaminated lobsters from Stonehaven. The low Cd Belledune lobsters probably recently migrated into the contaminated area. Cd concentration in the hepatopancreas was 5-8 times gill levels, and the gill Cd concentration was 30 times that of the tail muscle (483.2±153.1, 69.79±27.22, 2.18±1.28 ppm dry weight, respectively). The calculated AEC was highest in the muscle, followed by the gill, and then hepatopancreas, but in all cases was within the range expected for healthy unstressed individuals. Although small significant differences in AEC were found in the gills, between Belledune and Stonehaven lobsters, no correlation was observed between Cd levels and any of the biochemical parameters. No significant differences were found in ATP-ase activity between Cd contaminated and control lobsters.

There was also no significant difference in AEC and adenine nucleotides between Belledune lobsters with elevated Cd levels and those with Cd levels similar to Stonehaven controls.

Publication:

Haya, K., C.E. Johnston, and B.A. Waiwood, 1980. Adenylate energy charge and ATP-ase activity in American lobster (Homarus americanus) from Belledune Harbour. In: Cadmium Pollution of Belledune Harbour, New Brunswick, Canada, (J.F. Uthe and V. Zitko, editors). Can. Tech. Rep. Fish. Aquat. Sci. No. 963.

50. Adenylate Energy Charge (AEC) as an Indicator of Sublethal Xenobiotic Effects In Winter Flounder and Crab.

Scientific Contact:
K. Haya, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

The AEC is potentially useful as a biochemical indicator of pollutant stress with aquatic fauna. Enzymatic assay techniques for the analysis of ATP, ADP and AMP (i.e., AEC) from winter flounder livers frozen in liquid nitrogen were developed. The AEC of winter flounder livers was 0.69±0.03 (n=6). This lower than expected AEC was thought to be due to hydrolysis of ATP by ATP-ase. AEC of crab hepatopancreas was 0.82±0.03 (n=6).

51. Metallothionein Induction as a Sublethal Biological Indicator of Metal Pollution.

Scientific Contact:
S. Ray, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Work has started under contract, on isolating possible Cd-metallothionein from contaminated Belledune lobsters. Hepatopancreas, gill tissue and green glands have been taken from about 25 lobsters and stored at -65°C. Only the hepatopancreas is being tested now, and four batches have been put through Sephadex G-75 columns and monitored by UV absorption. Initial results show a chromatographic peak with spectral properties similar to Cd-metallothionein. The Cd-containing fraction has been freeze-dried and stored for further purification and amino acid analysis. Other peaks eluted from the column have also been stored for further investigation as to their nature.

52. Histology of the Hepatopancreas, Gill and Green Gland Tissues of Cadmium Contaminated Lobsters from Belledune Harbour.

Scientific Contact:

P. Odense, Fisheries and Oceans Canada
Halifax Laboratory, Halifax, Nova Scotia.

The hepatopancreas, gill and green gland tissues of 118 lobsters from the Belledune area were examined histologically by light microscopy using haemotoxylin and eosin stained material. The lobsters examined were all in their intermolt or early premolt stages (crustaceans are more susceptible to toxins during ecdysis). No histopathological changes were observed, regardless of Cd levels, in these tissues.

Publication:

Odense, P. and C. Annard, 1980. A Preliminary Study of the histology of the hepatopancreas, gill and green gland tissue of American lobsters (Homarus americanus) collected from the Belledune area of the Bay of Chaleur. In: "Cadmium Pollution of Belledune Harbour, New Brunswick, Canada". J.F. Uthe and V. Zitko (editors). Can. Tech. Rep. Fish. and Aquat. Sci. No. 963.

53. Di-2-ethylhexyl Phthalate (DEHP) Effects on Steroid Hormones in Cod (*Gadus morhua*).

Scientific Contact:
H.C. Freeman, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Cod which had been fed 0, 10, 100 or 1,000 μg of DEHP/g food for 121 days were dissected (liver, kidney, gonads) for histology and hormone metabolism studies. DEHP had little effect on the biosynthesis of steroid hormones in a previous *in vitro* study. In male fish there was no effect on steroidogenesis when head kidneys, and testes were incubated *in vitro* with radioactive steroid precursors. DEHP was accumulated mainly in the livers. There was, however, a significant alteration in steroidogenesis by the head kidneys, and ovaries in the female cod showing that DEHP has a sublethal chronic effect in this sex. The DEHP concentrations in the livers, ovaries and head kidneys of the females will be determined shortly. A histological examination is being carried out on the head kidneys, livers, testes and ovaries of the DEHP treated cod. The results of this ongoing project will be reported upon its completion.

Publication:
Freeman, H.C. and G. Sangalang. ICES C.M. 1979/E: 27.

54. Di-2-ethylhexyl Phthalate (DEHP) Effects on Androgens in Brook Trout (Salvelinus fontinalis).

Scientific Contact:
H.C. Freeman, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Levels of 1, 10, 100, and 1,000 μg/g in tissue in brook trout, altered hormone metabolism, in that synthesis of testesterone and 11-ketotestosterone was shifted to favor the pregnenolone, instead of the normal projesterone pathway. While this effect was noted at the 1 μg/g level, this is judged to be a less serious impact than that noted for other contaminants, such as PCBs or cadmium, which can also alter steroid hormone metabolism (e.g., brook trout, pigeon).

Publication:

Freeman, H.C., J.F. Uthe and G. Sangalang, 1980. The use of steriod horome metabolism studies in assessing the sublethal effects of marine pollution. Rapp. P.-v. Réun. Cons. Int. Explor. Mer. 179:16-22.

55. Metabolism and Toxicity of Petroleum Hydrocarbons in the Marine Food Chain.

Scientific Contact:
J.H. Vandermeulen, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Work on the mutagenic potential of hydrocarbons focused primarily on the water soluble fraction of petroleum hydrocarbons. Results indicate that the mutagenic potential is very low and that the direct toxic effect of the hydrocarbon in the water column is of greater significance than its mutagenic potential. On-going studies will include naturally weathered sedimented oils, in correlation with chemical analytical studies.

Brief exposure of marine phytoplankton to low sublethal concentrations of a broad range of contaminants elicited a deleterious response (disruption of normal swimming behaviour). Contaminants included petroleum hydrocarbons, PCBs, DDTs and heavy metals.

Publications:

Vandermeulen, J.H., T.C. Hemsworth and A. Foda. Chemical pollutant disruption of normal swimming behavior in the marine flagellate phytoplankton *Pavlova lutheri* Droop. In preparation.

Foda, A., J.H. Vandermeulen and C. Stottard. Mutagenic potential of water-soluble fractions (WSF's) of crude oils and oil products. In preparation.

56. Mutagenic Compounds in the Marine Environment.

Scientific Contact:
J. Payne, Research and Resource Services
Fisheries and Oceans Canada
St. John's, Newfoundland.

Chlorinated fresh and salt water extracts of a Venezuelan crude and No. 2 fuel oil were initially assayed and mutagenic activity observed. Waste waters which may enter the marine environment were subsequently chlorinated and methylene chloride extracts assayed for mutagenic activity. Ames TA100 tester strain of bacteria was routinely utilized. In addition, some extracts were also assayed with the frameshift TA1538 strain. Mutagenic activity was detected in methylene chloride extracts of swimming pool waters, chlorinated sewage, St. John's Harbour water and decomposing fish extracts. The residues were generally toxic, with 100 μl of fish and sewage extract resulting in 25-30% survival in fish. None of the waste water extracts assayed were mutagenic towards the TA1538 strain. Used engine oil, a major source of hydrocarbons in urban and municipal waste waters, was found to elicit enzyme mediated mutagenicity in a previous study.

Publication:

Payne, J.F., I. Martins, D. Tagan, and A. Rahimtula, 1979. Mutagens in aquatic environments: water chlorination and petroleum sources of polycyclic aromatics as major contributors. Contribution No. 380 from the MSRL, Memorial University of Newfoundland.

57. Effects of Spruce Budworm Spray Program on Migratory Forest Birds in New Brunswick.

Scientific Contact:
P.A. Pearce, Canadian Wildlife Service
Environment Canada, Fredericton, New Brunswick.

Research carried out since 1978 has shown significant behavioral changes and decreases in the productivity of migratory forest birds subjected to an over-dose of toxic sprays. Feeding experiments have shown that young and adult birds are affected by insecticides ingested with their food. Results of these studies indicated that sprays deposited at normal operational levels produced sublethal effects in birds.

During 1980, data collected in 1978-79 was analyzed and prepared for publication. Limited field work in 1980 concentrated on experimental feeding studies of nesting birds, and is expected to continue for at least four more years.

58. Sensitivity of Marine fish to *Gonyaulax* Toxins.

Scientific Contact:
A.W. White, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Studies to determine the sensitivity of salmon and cod to *Gonyaulax* toxins suggested that there are only minor species differences in responses. The oral LD50 is about 650 μg/kg, and the intraperitoneal LD50 is about 5-10 μg/kg for herring, pollock, flounder, cod and salmon. Low levels of toxins in muscle tissue, undetectable by bioassay, are apparently sufficient to cause paralysis and death.

59. Physiological Responses of Salmon (*Salmo salar*) and Trout (*S. gairdneri*) to Reduced pH.

Scientific Contact:
P.G. Daye, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

1. Structural Alterations

Sublethal alterations occurred in the integument, gills, blood and blood vascular structures of all live alevins incubated continuously at pH 5 and lower. At pH 4.5 and lower, injuries also occurred in the brain, optic retina, kidney, and spleen. Some tissue regeneration occurred in the embryonic rudimentary integument and to a lesser extent in the pseudobranch, kidney, spleen, and erythrocytes. Injury of the integument, the major site of respiration and ion exchange, was the apparent cause of death in pre-hatching embryos. Failure of tissue regeneration in the gill and brain during the alevin stage at sublethal acidic pH is predictive of poor survival in acid-stressed environments.

2. Acclimation

Acclimation to low pH, as judged by resistance adaptation, did not occur in 3 strains of salmon (Waweig River, Big Salmon River and Saint John River) and one strain of rainbow trout.

3. Hatching Success - Scientific Contact: R.H. Peterson, St. Andrews, New Brunswick

Hatching of Atlantic salmon eggs was delayed or prevented with pH exposures of 4-5.5 after eye pigmentation had developed. Hatching could be induced if the eggs were returned to a higher pH (6.6-6.8) within 8-10 days after the normal hatching time. Total egg mortalities were 0, 3, 30, 40, 37, and 97% at pH 6.8, 6.0, 5.5, 5.0, 4.5 and 4.0 respectively.

Publications:

Daye, P.G. and E.T. Garside, 1980. Structural alterations in embryos and alevins of the Atlantic salmon *Salmo salar*, induced by continuous or short-term exposure to acidic levels of pH. Can. J. Zool., Vol. 58, 1980.

Daye, P.G., 1980. Attempts to acclimate embryos and alevins of Atlantic salmon, *Salmo salar* and rainbow trout, *S. gairdneri* to low pH. Can. J. Fish. Aquat. Sci. 37:1035-1037.

Peterson, R.H., P.G. Daye and J.L. Metcalfe, 1980. Inhibition of Atlantic salmon (*Salmo salar*) hatching at low pH. Can. J. Fish. Aquat. Sci., Vol. 37:770-774.

60. Effects of pH on Salmon Egg Hatching Enzyme (Chorionase).

Scientific Contact:
K. Haya, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Exposure of *Salmo salar* eggs to acid conditions (pH 4.5) decreased the hatching success of the eggs. *Salmo salar* eggs were raised in acid (pH 4.5) or ambient (pH 6.3-6.8) water, or initially at ambient pH then at acid pH for 1-27 days. Chorionase (salmon egg hatching enzyme) was collected from these eggs and chorionase activity was determined. It was thought that changes in the mucopolysaccharide coating of the egg at acid pH may be more important than changes in chorionase activity on the hatching success of the egg. This work is in progress.

61. Effect of Contaminants on the Filtration Rate of Bivalve Mollusks.

Scientific Contact:
D.W. McLeese, Fisheries and Environmental Sciences
Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Studies were initiated to investigate the effect of contaminants on the filtration rates of bivalve mollusks. A dosing apparatus was built and tested in preliminary trials. The filtration rate of the mussel, *Mytilus edulis*, decreased with increasing concentration of the phytoplankton, *Dunaliella tertiolecta* (3-5.5 mg/L), according to the equation:

$$\text{Filtration rate (mL/h/animal)} = -175 \text{ conc. phytoplankton (mg/L)} + 1370.$$

In the presence of hexachlorobiphenyl (HPCB) in the exposure vessel, the filtration rate was elevated slightly with 0.1 ppm HPCB and depressed markedly with 10 ppm HPCB. The method showed promise for measuring the effects of contaminants on filtration rates, and for assessing the mechanism of contaminant uptake by bivalves.

62. Lethality of Endosulfan to Crangon Shrimp in the Presence of Varying Amounts of Sediment.

Scientific Contact:
S. Ray, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Knowledge of the effects of contaminants in sediments is important for assessment of the effects of dredging, dredge spoil disposal, and of the general hazard of chemicals in the environment. In continuation of studies in this area, the lethality of endosulfan (10 µg/L nominal conc.) to *Crangon* shrimp was determined with no sediment and with varying amounts up to 111 µg sediment/L present in the test containers. The LT50's for the shrimp increased from 6 h with no sediment present, to LT50 >96 h with 111 µg/L present. The reduction in lethality is attributed to adsorption of endosulfan on the sediment. The average measured concentration of endosulfan in the water ranged from 0.4 µg/L with no sediment to 0.1 µg/L with sediment at 111 µg/L. Further studies of lethality/ sediment sorption are planned with a variety of sediments, other organochlorine pesticides and other classes of compounds.

4. APPLIED ECOLOGICAL RESEARCH

63. Potential of Biological Agents in Control of Blackflys and Mosquitos - M.H. Colbo (p. 81).

64. Physiological, Developmental and Pathogenicity Studies of Fungi Parasitizing Forest Insects - A. Nolan (p. 82).

65. Effectiveness of "No Spray" Buffer Zones in the Spruce Budworm Spray Program - W. Ernst (p. 83).

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69. Fish Populations in the Nashwaak Experimental Watershed: Second Year of Post-Clearcut - J. Martin (p. 88).

70. Analysis of the Bay of Fundy - Gulf of Maine Ecological Systems - A. Hansen (p. 89).

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72. Rehabilitation of Urchin-Dominated Barren Grounds - B. Miller (p. 91).

73. Liming of Acid Lakes in Nova Scotia - W. Watt (p. 92).

74. Salmon Catches in Relation to pH in Nova Scotia Rivers - W. Watt (p. 93).

63. Potential of Biological Agents in Control of Blackflys and Mosquitos.

Scientific Contact:
M.H. Colbo, Research Unit on Vector Pathology
Memorial University of Newfoundland.

Bacillus thuringiensis var *israelensis* efficacy against blackflies is being tested in small Newfoundland streams. Dosage with an initial concentration of 1 x 10^5 viable cells/ml caused up to 100% mortality in larval simuliids. Non-target stream fauna associated with simuliid larvae were not markedly reduced. This program is continuing, and includes a pilot project on a small stream system to determine if blackfly control is possible with *B.t.i.*, plus field trials with *B.t.i.* against mosquitos.

Publications:

Colbo, M.H. and A.H. Undeen, 1980. Effect of *Bacillus thuringiensis* var *israelensis* on non-target insects in stream trials for control of simulidae. Mosquito News. 40:9151.

Undeen, A.H. and M.H. Colbo, 1980. The efficacy of *Bacillus thuringiensis* var *israelensis* against blackfly larvae (Diptera: Simulidae) in their natural habitat. Mosquito News. 40:9140.

64. Physiological, Developmental and Pathogenicity Studies of Fungi Parasitizing Forest Insects.

Scientific Contact:
A. Nolan, Associate Professor, Department of Biology
Memorial University, Newfoundland.

Research efforts have concentrated on fungi parasitizing the eastern hemlock looper and spruce budworm.

Future work plans include:

1. The development of fungal bioassay systems for inorganic pollutants.
2. The development of a fungal plaque technique for the detection of mycoviruses and other viruses as an indicator of viral levels in freshwater ecosystems.

Publications:

R.A. Nolan and K.M. Malone, 1978. Aerobic bacterial flora of the larval gut of the blackfly *Prosimulium mixtum* (Diptera: Simulidae) from Newfoundland, Canada. J. Med. Entomol., 14:641-645.

Dumphy, G.B. and R.A. Nolan, 1979. Effects of physical factors on protoplasts of *Entomophythna egressa.*

65. Effectiveness of "No Spray" Buffer Zones in the Spruce Budworm Spray Program.

Scientific Contact:
W. Ernst, Environmental Protection Service
Environment Canada, Dartmouth, Nova Scotia.

The efficacy of "no spray" buffer zones was investigated during 1980 with fenitrothion applications at 210 g a.i./ha in a water formulation using TBM aircraft equipped with TEE jet nozzles.

The results indicate that a 400 m "no spray" buffer zone surrounding a small lake was sufficient to reduce the incidental spray deposit of formulation on the lake surface by 92% and 80% respectively, after two sequential sprays compared to the unprotected lake.

With two exceptions, fenitrothion was undetected in sediment samples. These two exceptions were thought due to the collection of a wind driven slick of formulation along the edge of the windward shore of the unprotected lake.

During the 1981 spray season, monitoring of aquatic invertebrate drift and spray concentration in areas where Cyclosol 63 is part of the formulation will be undertaken. Air, water and deposit samples will be collected. Comparisons with other spray delivery techniques and spray formulations will be made.

Publication:
Ernst, W., G. Julien, K. Doe, R. Parker and G. Pelly, 1980. Environmental investigations of the 1980 spruce budworm spray program in New Brunswick. Environmental Protection Service Report.

66. Pesticide Evaluation System.

Scientific Contact:
V. Zitko, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

An evaluation system for pesticides used in forest spraying has been developed. Based on physico-chemical constants and application rates, the system will provide expected environmental concentrations (EEC) in a number of compartments. Used in conjunction with toxicological information, it will also provide a quantitative ranking of hazards.

67. Effects of Intensive Forest Harvest on Site Degradation by Nutrient Impoverishment.

Scientific Contact:
B. Freedman, Institute for Resource and Environmental Studies
Dalhousie University, Halifax, Nova Scotia.

The standing crops of major nutrients in trees and soils in a variety of forest types on a range of site classes in central Nova Scotia are being determined. Nutrient removal in conventional clearcut harvests compared to whole-tree clearcut harvests is being evaluated. In an all-aged Red Spruce-Balsam Fir stand, Canada Land Inventory site class 5 (severe limitations to growth of commercial forests), a 30% increment in efficiency of wood recovery via a whole-tree clearcut was obtained at the expense of increases of 99% in N removal, 93% loss of P, 74% of K, 54% of Ca, and 81% Mg. Although the removal of nutrients tied up in tree biomass is less than that of total soil pools, it may be large relative to the rather ephemeral "available" soil nutrient pools.

Future studies will look at other sites of different inherent fertility and species composition. Those sites capable of supporting intensive harvesting without significant loss of fertility or productivity will be identified.

Publications:

Freedman, B., R. Morash, and A.J. Hansen, 1980. Effects of harvesting biomass for energy on the nutrient status and long-term production of forest stands in Nova Scotia. In: Proceedings: Bioenergy Research and Development Seminar. Energy Project Office, N.R.C. (in press). 7 pp.

Freedman, B., A.J. Hanson, and J.P. Ogden, 1980. The effects of harvesting biomass for energy on the nutrient status and long-term productivity of selected forest sites in Nova Scotia. Report to Canadian Forestry Service, under contract 0SC79-00086. ENFOR Prepar. 70 pp.

68. Potential of Wood Resources for Fuel Supply in Nova Scotia.

Scientific Contact:
B. Freedman, Institute for Resource and Environmental Studies
Dalhousie University, Halifax, Nova Scotia.

Hardwood availability, especially in large holdings, was evaluated (G. Henry, M.Sc. Thesis). A survey of woodlot owners to determine their potential role in forestry management for energy production was carried out (N. Blain, M.Sc. Thesis). The environmental implications of wood fuel, including wood harvesting, processing and incineration, are now under investigation.

69. Fish Populations in the Nashwaak Experimental Watershed: Second Year of Post-Clearcut.

Scientific Contact:
J. Martin, Applied Fisheries Ecology, Fisheries and Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The 1980 estimates of fish populations in the Nashwaak Experimental Watershed, corresponding to the second year of post-clearcut operations, were based on electroseining carried out in July. In the control stream, the number of trout were in the middle of the range observed over the past eight years. Salmon numbers were lower than previously recorded and eels slightly more numerous. Species numbers in the clearcut area were generally within the range of pre-clearcut years, with the number of trout higher than in the previous five years. Trout numbers in the riparian strip area of the cut watershed were, however, slightly lower than ever recorded. All other species in this area were in the range of pre-treatment populations.

70. Analysis of the Bay of Fundy - Gulf of Maine Ecological Systems.

Scientific Contact:
A. Hanson, Institute for Resource and Environmental Studies
Dalhousie University, Halifax, Nova Scotia.

The objective is to create long-term scenarios of resource use and environmental management potential under various ecosystem-based approaches to marine policy. The Bay of Fundy - Gulf of Maine system was chosen as the central case for examination of current strategies to define and manage a large ocean unit.

Specific objectives include: (1) determination of the significant ecological linkages between the Bay of Fundy and Gulf of Maine systems, and the relevance of existing boundary and other restraints such as quotas to these linkages; (2) development for a comprehensive resource inventory atlas emphasizing distribution characteristics of biological stocks and other important resource features; and (3) an examination of the limitations on the feedback of information from U.S. and Canadian scientific research on resource dynamics and environmental assessment into marine policy and regulations.

71. Wetland Habitat Classification and Assessment.

Scientific Contact:
D.A. Smith, Canadian Wildlife Service, Environment Canada
Sackville, New Brunswick.

During 1980, the pilot project on coastal wetland classification in New Brunswick will be expanded. This work is being carried out in collaboration with Nova Scotia, which has been systematically cataloguing its freshwater wetlands for several years. Maps will be produced setting up habitat categories in the coastal zone.

72. Rehabilitation of Urchin-Dominated Barren Grounds.

Scientific Contact:
B. Miller, Invertebrates and Marine Plants Division
Fisheries and Oceans Canada, Halifax, Nova Scotia.

Laboratory studies were carried out to assess the quick lime method of controlling urchins and its effects on other invertebrates.

73. Liming of Acid Lakes In Nova Scotia.

Scientific Contact:
W. Watt, Resource Branch, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Crushed limestone was added to 3 acid lakes in Halifax County in 1980, using different methods of application. The pH of two of these lakes was raised from about 4.5 to 5.4 in one case, and 6.6 in the other. The pH of these lakes has been monitored since then and has fallen slowly to about 5.

In 1981, a similar experiment on a larger scale is proposed. The effects of liming on fish and invertebrates will be monitored. Some "baseline" data on invertebrates have already been collected at this site.

74. Salmon Catches in Relation to pH in Nova Scotia Rivers.

Scientific Contact:
W. Watt, Resource Branch, Fisheries and Oceans Canada
Halifax, Nova Scotia.

Data on catches of salmon on rivers in different pH ranges are being studied. Preliminary analysis indicated that the salmon catch on rivers currently below pH 5 has fallen steadily since about 1950, whereas the catch on rivers above pH 5 shows no trend. This work is in progress.

5. BASELINE ECOLOGY: BAY OF FUNDY

75. Pecks Cove Mudflat Study - D.C. Gordon (p. 96).

76. Intertidal Epibenthic Primary Production and Benthic Metabolism at Pecks Cove - B.T. Hargrave (p. 97).

77. Bioturbation of Pecks Cove Mudflat - D.C. Gordon (p. 98).

78. Spectral Analysis of Benthic Organisms and Sediment Chemical Variables on Pecks Cove Mudflat - D. Peer (p. 99).

79. Ecological Energetics of *Corophium volutator* at Pecks Cove - C. Hawkins (p. 100).

80. Microbial Ecology of the Bay of Fundy and Pecks Cove Mudflat - D.C. Gordon (p. 101).

81. Sediment Organic Matter Availability to Microbial Decomposition and Assimilation by Invertebrate Organisms - B.T. Hargrave (p. 102).

82. Energetics of Fish Feeding on the Pecks Cove Mudflat - T. Salinas (p. 103).

83. Planktonic Primary Production in the Bay of Fundy and Over the Pecks Cove Mudflat - N. Prouse (p. 104).

84. Sediment/Water Exchanges on the Peck Cove Mudflat - D.C. Gordon (p. 105).

85. Physical and Chemical Measurements of Sediments on the Pecks Cove Mudflat - D.C. Gordon (p. 106).

86. Sources of Organic Carbon in Pecks Cove Mudflat - F.C. Tan and D.C. Gordon (p. 107).

87. Nutrient and Organic Chemistry of the Bay of Fundy - D.C. Gordon (p. 108).

88. Chemical and Biological Analysis of Cumberland Water and Sediments - D.C. Gordon (p. 109).

89. Phytoplankton of the Bay of Fundy - A. Lakshminarayana (p. 110).

90. Descriptive Ecology of Subtidal Benthic Communities in the Bay of Fundy - D. Peer, P. Schwinghamer (p. 111).

91. Primary Production in Fucoid Algae on Rocky Shores - M.L.H. Thomas (p. 112).

92. Non-Cryptic Sublittoral Rocky Bottom Communities in the Deer Island Region - F. Page (p. 113).

93. Trace Metals in Suspended Particulate Matter in the Bay of Fundy - D.H. Loring (p. 114).

94. Shad Tagging Study in the Bay of Fundy - M. Dadswell (p. 115).

95. Shorebird Foraging and Life History of Corophium volutater (pallus) in Upper Bay of Fundy - P. Hicklin (p. 116).

96. Atlantic Herring Kills Caused by Gonyaulax excavata Toxins Transferred Through Herbivorous Zooplankton - A. White (p. 117).

97. Shellfish Toxicity versus Hydrographic and Meteorological Factors - A. White (p. 118).

98. Geophysical and Sedimentary Studies in the Chignecto Bay System - C.L. Amos (p. 119).

75. Pecks Cove Mudflat Study.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The structure and dynamics of the mudflat ecosystem has been the subject of an on-going multidisciplinary study. Detailed analysis and interpretation of the data will follow completion of the field program. Emphasis during 1980 was placed on studying processes and included: (1) expanding the study of epibenthic primary production and respiration to look at short term temporal variations and to examine the effect of variations in light intensity; (2) examining the light/photosynthetic relationships of the resident phytoplankton population; (3) investigating the flux of dissolved and particulate materials between the mudflat and seawater under both static and turbulent conditions; (4) studying in greater detail the ecological energetics of *Corophium volutator*, the dominant prey organism on the mudflat for fish and shorebirds; (5) studying the origin of organic carbon and food chain relationships on the mudflat using stable carbon isotope ratios; and (6) investigating bioturbation processes and effects. All field work terminated at the end of 1980. In 1981 data will be analyzed and the results published.

Publication:

Gordon, D.C., P.D. Keizer, J. Dale and P.J. Cranford, 1980. Pecks Cove mudflat ecosystem study observations in 1978. Can. Tech. Rep. Fish. Aquat. Sci., No. 928. Marine Ecology Laboratory, BIO.

76. Intertidal Epibenthic Primary Production and Benthic Metabolism at Pecks Cove.

Scientific Contact:
B.T. Hargrave, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Monthly production experiments continued at the intertidal stations through 1979 and 1980, terminating in November. In addition, production was measured over consecutive incubations of a few hours duration and on consecutive days to quantify short-term variability.

Preliminary calculations of rates of oxygen production and consumption showed generally similar rates at both sampling stations. Variation in primary production between days was strongly influenced by changes in levels of incident radiation. Benthic oxygen consumption was less variable. Shading experiments were initiated in July, 1980, to provide variation in light levels during one experimental period (rather than for comparison between days).

Upon completion of data analysis, a publication will be prepared concerning biological and physical factors regulating epibenthic primary production in intertidal regions of Pecks Cove.

77. Bioturbation of Pecks Cove Mudflat.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Bioturbation habits and rates of *Heteromastus*, an abundant deposit feeding polychaete at Pecks Cove, were studied. During the summer, individual worms transported 10-50 mg of deep (approximately 15 cm) sediment to the mudflat surface and deposited it as fecal pellets. These pellets were suspended and redeposited with tidal movement across the mudflat. Bioturbation was greatest at high temperatures and when the mudflat was inundated.

The data will be combined with available data on the bioturbation habits and rates of *Corophium* and *Macoma*, resulting in a publication on bioturbation of the Pecks Cove mudflat.

78. Spectral Analysis of Benthic Organisms and Sediment Chemical Variables on Pecks Cove Mudflat.

Scientific Contact:
D. Peer, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Different scales of spatial distribution were studied through measurement of the following variables: macrofauna, meiofauna, bacteria, pigments, organic carbon and nitrogen. Samples will be analyzed and interpreted during the winter, 1981.

79. Ecological Energetics of *Corophium volutator* at Pecks Cove.

Scientific Contact:
C. Hawkins, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The feeding ecology of *C. volutator* was studied during 1980. Field data indicates that approximately 90% of the population feeds at high tide, most probably in a turbid layer extending a few centimetres off bottom. Further laboratory and field studies are underway to determine feeding rates. These will be linked with future laboratory studies on respiration and excretion.

80. Microbial Ecology of the Bay of Fundy and Pecks Cove Mudflat.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Data from the fall, 1979, cruise showed an increase in bacterial numbers up the Bay, with the lowest numbers (0.81×10^6 ml) found mid-bay, and the greatest numbers (2.3×10^6 ml) found at the mouth of Cumberland Basin. Percentage of attached sediment bacteria and bacterial activity also increased up the bay. Additional bacterial samples were also collected at Pecks Cove mudflat to complete a seasonal sampling program. Data will be prepared for publication during 1981.

81. Sediment Organic Matter Availability to Microbial Decomposition and Assimilation by Invertebrate Organisms.

Scientific Contact:
B. Hargrave, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

During 1979, observations of bacterial biomass on various wet-sieved fractions of sediment showed that distribution was not simply a function of particle size. Fecal pellets had greater concentrations of bacteria compared to the more numerous sediment grains. Bacterial biomass and the organic content of various sediment types will be compared.

Particulate matter, collected in a multi-chambered settling trap monthly since March, 1980, has been analyzed for dry weight, organic carbon, nitrogen and pigment content. After dark incubation in sea water concentrations of dissolved nutrients, organic carbon, nitrogen and CO_2 were determined. Upon completion of analysis, seasonal changes in the rates of gas and nutrient exchange by particles accumulated in settling traps may provide a quantitative measure of the availability of organic matter for aerobic decomposition.

Date will be analyzed and summarized in a primary publication in 1981.

82. Energetics of Fish Feeding on the Pecks Cove Mudflat.

Scientific Contact:
I. Salinas, Biology Department
Dalhousie University, Halifax, Nova Scotia.

During 1979, six fish species were identified feeding on the mudflat: silversides, tomcod, flounder, smelt, stickleback, and mummichog. Gut analysis indicated that *Corophium* was the most important food item. In addition to movement through the creek channels, to and from the mudflat, fish moved with the tidal front.

Field collections terminated in the fall, 1980. An MSc. thesis has been prepared and submitted to Dalhousie University: Feeding strategies of *Microgadus tomcod* and *Menidia menidia*.

83. Planktonic Primary Production in the Bay of Fundy and over the Pecks Cove Mudflat.

Scientific Contact:
N. Prouse, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Planktonic primary production was measured using the radioactive carbon method. On four cruises in the Bay of Fundy, deck incubations simulating the light at different depths and light saturation experiments were performed. Results indicate that the highest production (9.0 mg C m^{-3} hr^{-1}) occurs. There was substantial production (2-7 mg C m^{-3} hr^{-1}) in the upper reaches of the bay where high amounts of suspended material is present.

At Pecks Cove, in-situ production experiments were done in conjunction with light measurements at various depths. Results indicate a photic zone of only 1-1.5 m, depending on incident light and suspended material. From the light saturation experiments, maximum assimilation numbers varied from near zero to 11 mg C (mg chlorophyll a$)^{-1}$ m^{-3} hr^{-1}, again a reflection of the high SPM. The response of the phytoplankton to suboptimal light intensities also varied much more at pecks Cove than in the outer Bay of Fundy. Annual production of the water over the mudflat was estimated at 16 g C m^{-2} hr^{-1}.

With completion of field work in 1980, all data will be presented in a technical report in 1981.

84. Sediment/Water Exchanges on the Pecks Cove Mudflat.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

A portable pumping system which sampled water 10 cm above the mudflat surface was used through the end of 1979. Results indicated that most material resuspended by an advancing tide settled very rapidly (10-15 minutes). In most instances there was no stratification in the water column over the mudflat. There were no significant differences in sediment organic carbon and nitrogen and plant pigment before and after high tide.

Dissolved oxygen, carbon dioxide, inorganic nutrients and organic carbon exchange between the sediments and water were measured under chambers placed over the sediment for 24 hours. As there were changes in dissolved nutrients, oxygen uptake and carbon dioxide release over 24 hours, it was thought that diel or tidal rhythms in metabolic activity may occur. Rates of gas flux, which varied seasonally, were highest during summer months in 1980.

Experiments in 1980 measured the flux of nutrients and dissolved organic carbon between sediments and water under turbulent conditions. Field work terminated in the fall. During 1981, analytical work will be completed, data analyzed, and interpreted and reports/publications prepared.

85. Physical and Chemical Measurements of Sediments on the Pecks Cove Mudflat.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Weekly and biweekly measurements were made at two stations on the mudflat during 1979. Sediment grain size, water content, pigments, organic carbon and nitrogen, total and available zinc, and erosion/deposition were measured. Most of these measurements continued in 1980, at monthly intervals, as part of the production/respiration experiments looking at seasonal variation in the mudflat.

Total, non-detrital, and detrital Zn concentrations in surface sediments have been analyzed for 1979. Total Zn varied from 55-94 ppm over this period, and was comparable to that found in texturally equivalent sediments elsewhere in the Bay of Fundy. Potentially bioavailable (non-detrital) Zn remained a relatively constant (8.2-10.2%) percentage of the total Zn concentration. Results suggest that all of the bioavailable Zn is natural and not influenced by industrial inputs, and is comparable to bioavailable Zn in similar sediments for the whole bay (approximately 10% of the total Zn concentrations) and the open Gulf of the St. Lawrence (9% of the total Zn).

86. Sources of Organic Carbon in Pecks Cove Ecosystem.

Scientific Contact:
F.C. Tan, Atlantic Oceanographic Laboratory and
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Stable carbon isotope methods are being applied to samples collected in Pecks Cove for the determination of the importance of different potential organic carbon sources relative to the total particulate organic carbon in surficial sediments and over-flooding seawater. Results will be applied to establishing the relative importance of different carbon sources to the maintenance of heterotrophic benthic organisms on the mudflats of Pecks Cove.

Samples of benthic diatoms, phytoplankton, *Spartina*, seaweeds, surficial sediments, suspended particulate matter and consuming organisms collected monthly by the Marine Ecology Laboratory were analyzed for C^{13}. Upon completion of analysis of samples in the summer, 1981, the results will be interpreted and prepared for publication.

87. Nutrient and Organic Chemistry of the Bay of Fundy.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

A grid of 16 stations spaced across and along the Bay of Fundy was sampled during March 1979, October 1979 and February 1980. Water samples were collected at five depths and analyzed for nitrate, nitrite, ammonia, phosphate, silicate, chlorophyll, phaeophytin, particulate organic carbon and nitrogen, and dissolved organic carbon. The Atlantic Geoscience Centre determined the suspended particulate matter concentrations in all samples, and a CTD (conductivity, temperature, density) record was obtained at each station, except during the March 1979 cruise.

All data supported the present concept of residual circulation in the Bay, that water flows in on the Nova Scotia side, moves across the Bay near Cape Chignecto, and flows down the Bay along the New Brunswick coast. The greatest primary production appeared to take place during the summer near the mouth of the Bay where thermal stratification was greatest. Primary production appeared to be light-limited throughout the entire Bay; the only possible nutrient limitation (nitrogen) occured off the New Brunswick coast in the lower Bay during the summer. Suspended particulate material varied considerably with season, with the greatest concentrations throughout the Bay occuring in the fall. During the winter, the concentrations of most variables were greatest at the mouth of Minas Channel, the mouth of Chignecto Bay, and along the New Brunswick coast in the upper Bay. This distribution suggested exports of both dissolved and particulate materials from the upper reaches of the Bay, which might be the result of ice effects in the intertidal zone.

88. Chemical and Biological Analysis of Cumberland Basin Water and Sediments.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Monthly samples have been collected using helicopters (79-80). Water samples were analyzed for temperature, salinity, SPM, nutrients, dissolved organic carbon, particulate organic carbon, nitrogen, pigments and bacteria. Sediment samples were analyzed for pigments, organic carbon, organic nitrogen, bacteria and meiofauna. This extensive data base has allowed quantification of the strong chemical and biological gradient along the axis of the Cumberland Basin and a comparison of the biological productivity of the major mudflats. Pecks Cove is apparently the most productive mudflat in the Cumberland Basin, perhaps because of its more sheltered nature.

Sampling will terminate in December, 1980, supplying almost two complete years of data. Once the analytical work is completed, data will be analyzed and a technical report prepared

89. Phytoplankton of the Bay of Fundy.

Scientific Contact:
A. Lakshminarayana, University of Moncton
Moncton, New Brunswick.

Preliminary analysis indicated that about 35 species of phytoplankton occurred in the open Bay of Fundy during summer and fall, with diatoms being the most abundant. The number of species in the upper reaches was less, about 26.

90. Descriptive Ecology of Subtidal Benthic Communities in the Bay of Fundy.

Scientific Contact:
D. Peer, P. Schwinghamer, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Identification and classification of benthic communities from the outer part of the Bay of Fundy are complete. Analysis and identification of samples from Chignecto Bay, Minas Basin and Channel are underway. Publication (1981) will address: (a) the relationship between benthic community distribution and environmental factors such as current velocity spectra, sediment type, and sediment chemistry; and (b) secondary production levels.

91. Primary Production in Fucoid Algae on Rocky Shores.

Scientific Contact:
M.L.H. Thomas, University of New Brunswick
Saint John, New Brunswick.

Primary production and respiration in *Ascophyllum nodosum*, *Fucus vesiculosus*, *F. edentatus* and *F. spirales* (90% of the intertidal algal biomass) was determined at a typical exposed site, Musquash Head, New Brunswick. Immersed algae were studied in-situ, using light and dark bottle oxygen experiments. Emmersed algae were investigated in the laboratory using infrared gas analysis with different percentage desiccation and temperatures and illumination levels.

Gross production in *A. nodosum* varied seasonally, with maximum levels occurring at around 11°C in June in algae from upper tidal levels. A similar pattern occurred in the *Fucus* species, but with greater maximum gross production. Significant net production occurred in all seasons at all tidal levels.

Associated ongoing experimental work is determining field conditions of light, temperature and dessication. The emmersed algae laboratory experiments showed that production was strongly affected by these parameters.

Final results will be available in 1981.

92. Non-Cryptic Sublittoral Rocky Bottom Communities in the Deer Island Region.

Scientific Contact:
F. Page, University of New Brunswick
Saint John, New Brunswick.

Three sample sites, Simpson, Spruce and Casco Islands were chosen on the basis of the bottom profiles being relatively steep and consisting mainly of bedrock. For each site, a bottom depth profile was constructed, photographs were taken at 15 foot intervals, and unknown species collected.

Preliminary analysis of field data and photographs showed a decrease in sea urchin abundance with depth from about 80 urchins/sq m in shallow water, to 10 urchins/sq m at 10-13 m depth.

Community composition 0.16 m below MLW was dominated by encrusting coralline algae and Petrocelis sp, together covering 70-80% of the available substrate surface. Terebratulina, Acmea, and chitons (Tonicella spp), were the most abundant fauna present. At depths greater than 20 m, sponges increased, becoming dominant at 30-35 m.

93. Trace Metals in Suspended Particulate Matter in the Bay of Fundy.

Scientific Contact:
D.H. Loring, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The abundance and distribution of Si, Al, Fe, Mn, Ca, Mg, Na, Zn, Cu, Pb, Cd were determined in suspended particulate matter (SPM) samples from 60 stations and 4 or 5 depths in the water column. Exceptionally high levels of Cd (4-180 ppm) occurred in the first data set of 1977 at various depths and locations in the Bay. Surface samples taken in March, August and October, 1979, confirmed the existence of Cd-rich (2-54 ppm) particles in the Bay.

Investigations on the dispersal of metal enriched particles in SPM samples from the last 3 or 4 cruises will continue.

Data obtained on the variation of trace metals in SPM during a tidal cycle at the head of the Bay will be combined with SPM fluxes over tidal cycles to determine the amount of trace metals transferred in and out of the upper reaches of the bay over different time periods. Data on the geochemistry of the SPM for major and trace metals will be prepared for publication during 1981.

94. Shad Tagging Study in the Bay of Fundy.

Scientific Contact:
M. Dadswell, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Shad (2,200), were tagged in Cumberland Basin in 1980 as part of the study to determine the degree of utilization of the basin by commercial species. Indications from tag returns were that shad had a residence time in the Basin of about 1 week, and showed up in order in Shepody Bay 10 days to 2 weeks later. Recent tag returns from the 1979 release have been obtained from the James River, Virginia, two from the St. Lawrence River and one from a cod net north of western P.E.I.

95. Shorebird Foraging and Life History of *Corophium volutator* (pallus) in the Upper Bay of Fundy.

Scientific Contact:
P. Hicklin, Canadian Wildlife Service
Environment Canada, Sackville, New Brunswick.

Data on the distribution and numbers of shorebirds around the Bay of Fundy, and on their invertebrate prey, were collected in 1976-1980. Field work (1980), included further studies of the relative feeding use of different tideflat levels by Semipalmated Sandpipers, and preliminary studies of feeding by Black-bellied Plovers. A limited mud sampling program was included; results will be compared to Northumberland strait mud samples collected in 1978.

Preliminary attempts to trap and band shorebirds on the mudflats were undertaken in order to estimate the length of stay of individual birds. Data will be used to show the rate of fat deposition and the efficiency of food conversion, and to determine population turnover rates for estimation of total numbers passing through the area.

The Sandpiper concentrated its feeding in the upper and middle zones of the intertidal flats where the densities of *Corophium* were highest. Some mudflats accommodated 100,000 foraging sandpipers. Although shorebirds had a significant impact on the *Corophium* population, the preys' high reproductive and growth rates maintained substantial levels of available food for shorebirds throughout migration.

96. Atlantic Herring Kills Caused by *Gonyaulax excavata* Toxins Transferred Through Herbivorous Zooplankton.

Scientific Contact:
A. White, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Adult herring kills occurred in the southwestern Bay of Fundy during the 1979 annual bloom of *Gonyaulax excavata*. Herring were collected from the kill sites and stomach contents analyzed. *G. excavata* toxins ranged from 64-245 µg/100 g stomach, caecae and intestines. Stomachs also contained the cladoceran *Evadne nordmanni*, dominant in the zooplankton community at the time. As bioassays showed the presence of *G. excavata* toxins in the zooplankters (18 µg/g wet plankton) it was concluded that *E. nordmanni* was the primary vector of toxin transmission to herrng. It was thought that the toxic transfer mechanism, from herbivorous zooplankton to fin-fish, may be a general phenomenon.

Publication:
White, A.W., 1980. Recurrence of kills of Atlantic Herring (*Clupea harengus harengus*) caused by dinoflagellate toxins transferred through herbivorous zooplankton. Can. J. Fish. Aquat. Sci. 37: 2262-2265.

97. Shellfish Toxicity Versus Hydrographic and Meteorological Factors.

Scientific Contact:
A. White, Fisheries and Oceans Canada
St. Andrews, New Brunswick.

Monthly clam and mussel toxicity data for the period 1944-1980 for several areas in the southwestern Bay of Fundy have been logged on computer cards. Data for hydrographic and meteorological parameters for the same period were also included (temperature, salinity, sunshine, wind and river runoff for three locations). Data listings, monthly and annual means and associated statistics, and correlation coefficients have been obtained. Results will be used to test hypotheses to predict the timing and severity of summer *Gonyaulax* blooms.

98. Geophysical and Sedimentary Studies in the Chignecto Bay System.

Scientific Contact:
C. Amos, Atlantic Geoscience Centre
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

A multidisciplinary survey of Chignecto Bay has been underway since 1978. Evaluation of the Minas Basin system has entailed analysis of the present sediment character and distribution, the budget of the various types of sediments, their sources, the transport of sediment in suspension and as bedload to the site of deposition, and the post-glacial development of these variables.

Concentrations of suspended materials ranged from less than 1 mg/L to more than 2,700 mg/L . Most of the material entering Minas Basin was derived from bordering, eroding cliffs and was predominantly sand-sized. Silt/clay size material was derived mainly from the Bay of Fundy and, to a lesser extent, rivers discharging into the system. Most of bedload motion occurred in the sand fraction and took place within the intertidal zone. There was a strong flux of suspended material, which is principally controlled by the residual tidal current in the subtidal region, and perhaps by current speed nearer to shore. Suspended material was being advected eastward into Cobequid Bay and south into Windsor Bay at rates from 0.1×10^6 g/m^3/tide to 3.5×10^6 g/m^3/tide.

The data from this study will be used to develop a predictive model assessing siltation resulting from potential tidal power development in this area.

Publications:

Amos, C.L, and B.F.N. Long. The sedimentary character of Minas Basin, Bay of Fundy.

Amos, C.L. and K.W. Aspry, 1979. Geophysical and sedimentary studies in the Chignecto Bay System, Bay of Fundy - a progress report in current research, Part B. Geological Survey of Canada, Paper 79-1B, pg. 245-252.

6. WILDLIFE SURVEYS/INVENTORIES

99. Baseline Studies of East Newfoundland Seabird Colonies - D.N. Nettleship (p. 122).

100. Colonial Bird Surveys - A.R. Lock (p. 123).

101. Monitoring Numbers and Nesting Success of Migratory Birds - T. Erskin (p. 124).

102. Eider Studies In Labrador - A.R. Lock (p. 125).

103. Waterfowl Banding and Survey Operations in the Maritimes and Newfoundland - W.R. Whitman, R.I. Goudie (p. 126).

104. Waterfowl Surveys in Labrador - W. R. Whitman, R.I. Goudie (p. 127).

105. Distribution of Land Birds in Newfoundland - W.A. Montevecchi (p. 128).

106. Annual Woodcock and Snipe Surveys - W.R. Whitman (p. 129).

107. Preliminary Assessment of Endangered Whales in the Lower Bay of Fundy - R.R. Reeves (p. 130).

108. Wildlife Inventories in the National Parks of the Atlantic Region - W.H. Prescott (p. 131).

109. Lynx-Bobcat Project on the Cape Breton Highlands, Nova Scotia - G.R. Parker (p. 132).

110. Population Dynamics of the George River Caribou Herd in Labrador - G.R. Parker (p. 133).

99. Baseline Studies of East Newfoundland Seabird Colonies

Scientific Contact:
D.N. Nettleship, Canadian Wildlife Service
Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

During 1980, procedures and study plots for monitoring numbers of burrowing seabirds (Atlantic Puffin, Leach's Storm-Petrel) were established with sufficient accuracy to detect the effects of losses away from the breeding area. Standardized methods for monitoring murre numbers have been published.

Publication:
Birkhead, T.R. and D.N. Nettleship, 1980. Census methods for murres, *Uria sp*: A unified approach. Occational Paper No. 43. Canadian Wildlife Service.

100. Colonial Bird Surveys.

Scientific Contact:
A.R. Lock, Canadian Wildlife Service, Dartmouth, Nova Scotia.
A.D. Smith, Canadian Wildlife Service, Sackville, New Brunswick.

The results of the 1978 survey of P.E.I. colonies of gulls, terns, cormorants, and herons, and 1979 surveys of colonies in southwestern New Brunswick have recently been reported.

The preliminary catalogue of Maritime heron colonies was updated. Colony size, chronology of breeding, and nesting success were determined in a sample of heron colonies in late June-early July, 1980.

101. Monitoring Numbers and Nesting Success of Migratory Birds.

Scientific Contact:
T. Erskin, Canadian Wildlife Service
Sackville, New Brunswick.

During 1980, most of the surveys in the 1979 cooperative Breeding Bird Survey (BBS) were repeated.

The Maritimes Nest Record Scheme in 1979 contained over 23,000 records for 184 species of birds, with another 1200-1400 additional records anticipated in 1980.

102. Eider Studies in Labrador.

Scientific Contact:
A.R. Lock, Canadian Wildlife Service
Dartmouth, Nova Scotia.

Extensive aerial surveys and follow-up ground studies are being conducted in order to determine the present breeding distribution, and to assemble data towards a population estimate of eiders breeding in Labrador.

103. Waterfowl Banding and Survey Operations in the Maritimes and Newfoundland.

Scientific Contact:

W.R. Whitman, Canadian Wildlife Service, Sackville, New Brunswick.
R.I. Goudie, Canadian Wildlife Service, St. John's, Newfoundland.

Increased efforts in 1980 were directed toward Newfoundland, with one crew working successively in Birchy Basin and Codroy, and another in Carmanville and Terra Nova National Park. In the Maritimes, banding continued at Bathurst, the Saint John River Basin, Amherst, and in National Wildlife Areas from Wallace Bay to Shepody. Preliminary breeding population estimates will be completed and published in 1980-81.

104. Waterfowl Surveys in Labrador.

Scientific Contact:
W.R. Whitman, Canadian Wildlife Service, Sackville, New Brunswick.
R.I. Goudie, Canadian Wildlife Service, St. John's, Newfoundland.

Helicopter surveys of the Smallwood Reservoir area, carried out in 1970 before the reservoir was filled, were repeated in 1980. Additional ground surveys were carried out in each study block, in order to investigate breeding density, species composition, and habitat use.

The first extensive aerial (fixed wing) surveys of southern interior Labrador will also be carried out with systematic ground-checking.

105. Distribution of Land Birds in Newfoundland.

Scientific Contact:
W.A. Montevecchi, Memorial University
St. John's, Newfoundland.

The habitat distribution and seasonal movements of land birds are being surveyed across the island to develop baselines from which environmental assessment studies can be generated. The effects of habitat disturbance and pesticide spraying are being sought.

106. Annual Woodcock and Snipe Surveys.

Scientific Contact:
W.R. Whitman, Canadian Wildlife Service
Sackville, New Brunswick.

Volunteers and wildlife technicians index woodcock populations by carrying out evening counts of calling birds along randomly selected roadside routes. During hunting season, selected hunters are asked to send in wings from each woodcock or snipe they kill. Examination of these wings allows segregation of age and sex, and thus an estimate of productivity and relative vulnerability to hunting pressure. In addition, the proportion of unprotected shorebirds shot in mistake for snipe is obtained.

107. Preliminary Assessment of Endangered Large Whales in the Lower Bay of Fundy.

Scientific Contact:
R.R. Reeves, New England Aquarium, Boston, Mass.

A series of aerial surveys of cetaceans in the lower Bay of Fundy was conducted during the summer, 1980. Fin and right whales were consistently present, while humpback whales were seen infrequently. Results suggest that this area may be a critical area for a significant segment of the western North Atlantic right whale population.

108. Wildlife Inventories in the National Parks of the Atlantic Region.

Scientific Contact:
W.H. Prescott, Canadian Wildlife Service
Sackville, New Brunswick.

During 1979, wildlife inventories were completed at Cape Breton Highlands, Terra Nova, Prince Edward Island, and Gros Morne National Parks. Reports were submitted in 1980.

During 1980, a study was initiated to investigate the possibilities for re-introducing pine martin into parks.

109. Lynx-Bobcat Project on the Cape Breton Highlands, Nova Scotia.

Scientific Contact:
G.R. Parker, Canadian Wildlife Service
Sackville, New Brunswick.

During 1976-79, in cooperation with provincial wildlife staff, the Canadian Wildlife Service studied the population dynamics of lynx and bobcat in relation to the cyclic snowshoe hare population. The hunting behaviour and social interactions of lynx were also studied in detail. During 1980 several publications were released.

110. Population Dynamics of the George River Caribou Herd in Labrador.

Scientific Contact:
G.R. Parker, Canadian Wildlife Service,
Sackville, New Brunswick.

The objective was to study the population dynamics and health of this herd, which ranges between Quebec and Labrador. This project will also contribute to studies on wolf predation and the economic feasibility of commercial caribou harvesting. A final report is expected in 1981.

7. BASELINE ECOLOGY

111. Baseline Ecological Studies of Winter Flounder in Conception Bay, Newfoundland - D.L. Fletcher (p. 135).

112. Baseline and Ecological Field Research on Midwater and Benthic Communities Associated with Submarine Canyons of the Southeastern Grand Bank - R.L. Haedrich (p. 136).

113. Seabird Ecology - W.A Montevecchi (p. 137).

114. Distribution of Seabirds: Pelagic Ecology - D. Brown (p. 138).

111. Baseline Ecological Studies of Winter Flounder in Conception Bay, Newfoundland.

Scientific Contact:
G.L. Fletcher, Marine Sciences Research Laboratory
Memorial University of Newfoundland, St. John's, Newfoundland.

Long term seasonal studies on a population of winter flounder (*Pseudopleuronectes americanus*) in Conception Bay, Newfoundland, are being conducted. Flounder are collected at monthly intervals throughout the year and a wide variety of parameters measured. These include feeding, monthly growth rates, tissue Cu^{+2}, Zn^{+2}, Ca^{+2} and Mg^{+2} concentrations, red blood cell numbers and types, plasma electrolytes and plasma protein antifreeze levels. The results of this investigation provide detailed baseline data for Newfoundland winter flounder living in an uncontaminated environment. Populations of winter flounder from other parts of Newfoundland and Nova Scotia are also being studied and compared with the Conception Bay population.

Publications:

Fletcher, G.L. and M.J. King, 1978. Seasonal dynamics of Cu^{++}, Zn^{++}, Ca^{++} and Mg^{++} in gonads and liver of winter flounder (*Pseudopleuronectes americanus*): Evidence for summer storage of Zn^{++} for winter gonad development. Can. J. Zool. 56:284-290.

Fletcher, G.L. and J.C. Smith. Seasonal changes in plasma Cl^- and freezing point depression in Nova Scotian and Newfoundland winter flounder: Evidence for population differences in the timing of the annual cycle of plasma "antifreeze" levels. Can. J. Zool. In Press.

112. Baseline and Ecological Field Research on Midwater and Benthic Communities Associated with Submarine Canyons of the Southeastern Grand Bank.

Scientific Contact:
R.L. Haedrich, Department of Biology
Memorial University of Newfoundland
St. John's, Newfoundland.

Emphasis is on defining the assemblages present, describing patterns of vertical distribution, and determining trophic inter-relationships and the autecology of dominant species. This project had its first research cruise on R/V GADUS ATLANTICA in June, 1980. Sampling was done with 15' Isaac-Kidd midwater trawls, 41' Gulf of Mexico shrimp trawls, and Ponar grabs over the depth range 80 to 1500 meters. Future sampling is planned to 3000 m.

Lanternfishes (family Myctophidae) are being studied from deep water of the Grand Bank, Flemish Cap, and offshore Labrador. Emphasis is on the development of keys to adults and larvae, zoogeography, and ecology. The GADUS ATLANTICA collections total only about 5 species with one, *Benthosema glaciale*, extremely abundant.

113. Seabird Ecology.

Scientific Contact:
W.A. Montevecchi, Memorial University of Newfoundland
St. John's, Newfoundland.

The energetics, foods (seasonal fluctuations), feeding and development of North Atlantic marine birds are being investigated. These data, in conjunction with current census information, will be used to estimate food requirements of seabird populations. Baseline data on food and parental feeding rates are being developed as ecological assays of fisheries and oceanic conditions.

114. Distribution of Seabirds: Pelagic Ecology.

Scientific Contact:
D. Brown, Candian Wildlife Service
Dartmouth, Nova Scotia.

Intensive studies of seabirds around the "tidal pump" upwellings off Brier and Deer Islands, at the mouth of the Bay of Fundy, were carried out in 1974-1978. During 1980, an intensive survey of the Strait of Belle Isle in autumn and cruises on the Scotia Shelf to survey plankton (fish and seabird food) was conducted.

8. BASELINE CHEMICAL OCEANOGRAPHY

115. Sediment Transport and Bioturbation Studies in the Bay of Fundy - J.M. Smith (p. 140).

116. Sediment Transport, Deposition and Bioturbation Studies on the Newfoundland Slope - J.M. Smith (p. 141).

117. Estuarine and Coastal Trace Metal Geochemistry - P.A. Yeats (p. 143).

118. Atmospheric Deposition of Metals into the Coastal Zone - P.A. Yeats (p. 144).

119. Organic Chemicals in Atmospheric Phases - G. Lord (p. 145).

120. Natural Marine Organic Constituents - R. Pocklington (p. 146).

115. Sediment Transport and Bioturbation Studies in the Bay of Fundy.

Scientific Contact:
J.M. Smith, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Major pathways and sources of sediment in the vicinity of Grand Manan Island and Point Lepreau, where there is net sediment accumulation, were studied. Unusually high fluxes of Pb-120 to the sediments could not be explained solely on the basis of the particle accumulation rate. This was probably a consequence of sediment resuspension, particle interactions and sediment bioturbation phenomena. Radionuclide measurements on box and gravity core samples, modelling of bottom currents, seasonal measurements of primary benthic production, and characterization of macrofaunal communities will be used to identify sediment transport pathways and interactions.

116. Sediment Transport, Deposition and Bioturbation Studies on the Newfoundland Slope.

Scientific Contact:
J.M. Smith, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The distribution of Pb-210 and Cs-137 activity distributions in sediments of the Newfoundland slope in relation to bioturbation and sediment transport were investigated. Sediment samples collected in 1977 and analyzed for Pb-210 were used to determine the three-dimensional configuration of bioturbation artifacts in slope sediments. Samples taken from a three-dimensional grid superimposed on a box core are now being analyzed for Pb-210 and faunal contents in order to examine bioturbation artifacts on a small scale on horizontal as well as vertical sedimentary axes.

Pb-210 and Cs-137 measurements have also been made upon box core samples from the Atlantic Abyssal Plain in conjunction with an AGC project associated with nuclear waste disposal in the ocean. Results will be used to determine the effects of bioturbation and other post-depositional redistribution phenomena on trace metal and nutrient profiles in the interstitial waters of the sediments.

As this work has relevance to the study of the transport and fate of radionuclides dumped in the ocean from low-level and potential high-level dumping operations, it will be continued. Efforts will be made to coordinate the work with studies of trace metal geochemistry and nutrient and organic matter regeneration.

Publication:

Smith, J.M. and C.T. Schafer. Bioturbation of surficial sediments on the continental slope, east of Newfoundland. Proceedings of the Third Seminar on Marine Radioecology. Tokyo, Oct. 1-5, 1979, Nuclear Energy Agency, 225-237, 1980.

117. Estuarine and Coastal Trace Metal Geochemistry.

Scientific Contact:
P.A. Yeats, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Samples were collected in the estuary and Gulf of St. Lawrence during low river runoff conditions to complement studies previously carried out under high runoff conditions. Samples collected in 1979 will be analyzed, and the data interpreted during 1980/81. On board analytical instrumentation will then be employed during a future cruise, to examine speciation of metals in the mixing zone and turbidity maximum of the St. Lawrence estuary.

Publication:
Yeats, P.A., and J.M. Bewers. Trace metal discharges from the St. Lawrence River. Canadian Journal of Fisheries and Aquatic Sciences, in press.

118. Atmospheric Deposition of Metals into the Coastal Zone.

Scientific Contact:
P.A. Yeats, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The objective is to estimate the fluxes of trace metals from atmospheric deposition to particular coastal zones, e.g., Gulf of St. Lawrence, in order to compare such fluxes with those from river runoff. Sampling is intended to commence at a site near St. Margarets Bay in the near future. Long-term measurements at selected coastal sites will then be taken in order to make flux estimates for particular coastal embayments or marginal seas.

119. Organic Chemicals in Atmospheric Phases.

Scientific Contact:
G. Lord, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

In order to more completely assess the various contributions of organic material to the coastal zone, a program has been instituted in which the transport of organic chemicals to the ocean by the atmosphere is determined.

Initial efforts included a literature review and the development of suitable techniques for the analysis of ambient air and wet precipitation. A pilot sampling program, at a coastal site near St. Margarets Bay, has been started and samples collected for GC and GC/MS analysis of their organic constituents. A laboratory study has also begun to investigate the effect of salinity on Henry's Law constants, used in calculations of the gaseous ocean-atmosphere exchange. Investigation to date reveal Henry's Law constants applicable to seawater were 50% greater than corresponding values for freshwater.

Sample collection will continue at the present location. Once methodology is proven, sampling will extend to further sites in the vicinity of major water bodies, e.g., Gulf of St. Lawrence, in order to examine the spatial variability of the depositional fluxes.

Publication:

Lord, G. and R. Pocklington. Transport atmospherique et echange atmosphere-ocean de composes organiques a l'etat de traces. Journal de Recherches Atmospheriques, in press.

120. Natural Marine Organic Constituents.

Scientific Contact:
R. Pocklington, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Assessments have been made of the identity and distribution of predominant natural organic compounds in the marine environment. Initial work involved extracting and examining, using LGC and GC/MS techniques, the organic compounds produced by a cultured diatom Skeletonema costatum. Extraction of dissolved organic compounds from sea water is now in progress. It is intended in future to utilize XAD-2 and liquid-liquid extraction techniques in conjunction with a cooperative program with the Institute fur Meereskunde an der Universitat Kiel.

This long term program will involve developing and proving sampling and analytical techniques, and will also augment capabilities with regard to measuring the increasing anthropogenic releases of organic compounds.

9. BASELINE PHYSICAL OCEANOGRAPHY

121. Effect of Salinity, Temperature, Turbulence, Flocculation, and Particle Concentration on Particle Behaviour - K. Kranck (p. 148).

122. Particulate Matter Variability in Petpeswick Inlet - K. Kranck (p. 149).

123. Bottom Drifters - D. Bezanson (p. 150).

124. Surface Drifters - D. Bezanson (p. 151).

125. Laurentian Channel Current Measurements - G. Bugden (p. 152).

126. Wave Climate Studies - H.A. Neu (p. 153).

121. Effect of Salinity, Temperature, Turbulence, Flocculation, and Particle Concentration on Particle Behaviour.

Scientific Contact:
K. Kranck, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Suspended and bottom samples from a wide variety of environments are being collected. About 80 samples have been obtained mainly from the Atlantic Continental Shelf and Slope, and from Grand Lake, Nova Scotia. Results substantiated a general model for differentiating flocculated and unflocculated particle populations. It was concluded that organic matter flocculates even when salinity is an insignificant factor.

Future work on natural particle distributions will concentrate on determining particle size characteristics through the use of apparatus such as in-situ filtration equipment, optical or electronic sensors, and submersibles, and through studies of glacial sediments.

122. Particulate Matter Variability in Petpeswick Inlet.

Scientific Contact:
K. Kranck, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Total suspended particulate matter concentration and grain size spectra, total and living particulate carbon, and dissolved nitrogen and carbon were measured at stations along the length of Petpeswick Inlet and over several tidal cycles. Mixing of water masses and temporal periodicities caused variance in particle concentration and spectral shape which corresponded to seasonal, tidal, and seiche variations. Small scale variability of suspended particulate matter associated with turbulence fluctuations was thought likely to occur in all embayments. A process of transformation of organic matter between dissolved and particulate states, by aggregate formulation and breakup in response to turbulent changes, may explain the latter variability.

Publication:
K. Kranck. Variability of particulate matter in a small coastal Inlet, 1980. Can. J. Fish. & Aquatic Sci. In press.

123. Bottom Drifters.

Scientific Contact:
D. Bezanson, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Bottom drifters have been used in several applications related to ocean dumping sites and a fish larval study in Miramichi Bay.

Standard Woodhead bottom drifters were deployed at a number of ocean dumping sites by the dredging agencies. In the near future, the accumulated data will be interpreted to provide an atlas of bottom drift in the vicinity of the major ocean dump sites, and in other areas of interest.

124. Surface Drifters.

Scientific Contact:
D. Bezanson, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

This project provides information on surface drift in coastal waters, which may be utilized in oil drift simulations.

A new plastic surface drifter was developed and intercomparison studies carried out. A system for transmitting data to and from MEDS after compilation at BIO was developed.

The accumulated data will be interpreted and presented in an atlas of surface drift in the areas of application, so it can be compared to presently existing surface drift charts.

125. Laurentian Channel Current Measurements.

Scientific Contact:
G. Bugden, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Direct measurement over several years of current, temperature, and salinity at 5 locations in the Laurentian Channel of the Gulf of St. Lawrence has been undertaken. Long-term changes in the circulation of the deeper waters of the Gulf, and the possible relationship between such changes and differences in the quantity of freshwater runoff into the Gulf are being investigated.

Data analysis will continue through 1981, and results will indicate if the mooring program should continue.

126. Wave Climate Studies.

Scientific Contact:
H.A. Neu, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The objective is to establish for the Canadian coastal and northern waters, reliable monthly, annual and long-term sea state descriptions, based on synoptic wave charts issued by the Meteorological and Oceanographic Weather Centre, Halifax. The results of these studies have immediate application in problems such as determining the design wave height for oil-production installations and other structures in areas such as the Grand Banks and Sable Island. A Canadian coastal wave climate atlas, using three years data from 1978 to 1980, is being developed.

Long-term fluctuations in wave heights, apparently with a 6 year cycle were observed on the Scotian Shelf. The magnitude of this variation was nearly as large as the seasonal variation between winter and summer annually.

Studies on fluctuations in wave height for the whole Canadian coast and Continental Shelf, and for the North Atlantic will continue in order to provide better, long-term height predictions.

10. MODELLING STUDIES

127. Bay of Fundy-Gulf of Maine Modelling Studies - D. Greenberg (p. 155).

128. Formulation of Carbon Budgets - D.C. Gordon (p. 157).

129. Modelling of Forced Flow in the Strait of Canso - D.J. Lawrence (p. 158).

130. Modelling of Topographic Effects on Tidal Currents - K. Tee (p. 159).

131. Time-Dependent Estuary Models - G.E. Seibert (p. 160).

132. Iceberg Drift Track Prediction - E.G. Bankes (p. 161).

133. Oil Trajectory Analysis - D. Lawrence (p. 162).

127. Bay of Fundy-Gulf of Maine Modelling Studies.

Scientific Contact:
D. Greenberg, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

The purpose of modelling this area is to predict changes in tides resulting from a tidal power barrier in the upper bay.

Suspended sediment transport is being modelled to determine if the barrier will result in siltation analogous to that of causeways in the upper bay. Suspended sediment properties and characteristics in the Minas Basin were examined for input into a suspended sediment model. After measurement of sediment movement to calibrate the model, simulation of the operational tidal power plant was made. A tidal power barrier in Minas Basin was predicted to not result in siltation similar to the Windsor and Moncton causeways. Consideration is being given to applying the model to data from Chignecto Bay and to development of a bedload model for coarse sandy material.

The Fundy-Maine model is being adapted to model the barotropic residuals due to tides and mean seasonal wind stress. Residual circulation in this area has important impacts on fisheries and pollution. The model was further modified (after inclusion of non-linear terms) to include a wind stress term and the barotropic effects of the Saint John River discharge. Model results demonstrated some of the observed residual motions (e.g. the gyre around Georges Bank which opens in winter months, the clockwise circulations around Grand Manan Island) but not the large observed counter-clockwise surface circulation in the Bay of Fundy and Gulf of Maine area.

The numerical procedure, data, and other physical processes, such as baroclinic and freshwater effects, will be examined with regard to the discrepancies prior to preparing this work for publication.

Publication:

Greenberg, D.A., 1979. A numerical model investigation of tidal phenomena in the Bay of Fundy and Gulf of Maine. Marine Geodesy, 2, 161-187.

128. Formulation of Carbon Budgets.

Scientific Contact:
D.C. Gordon, Marine Ecology Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Sub-models of key processes, such as seawater/sediment carbon flux, sediment carbon production and respiration, and carbon budgets for major species, will be developed for the Bay of Fundy.

129. Modelling of Forced Flow in the Strait of Canso.

Scientific Contact:
D.J. Lawrence, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

A numerical model of the flow field was constructed in order to examine the role of the Canso Causeway in the decline of various fish stocks in eastern Nova Scotia. The model was one dimensional, vertically averaged and driven by the tidal elevations at each end. The model predicted a predominance of south-going flow with exchange occurring on most tidal cycles. This suggested that in the pre-causeway era, flow of larval-bearing waters from St. Georges Bay to Chedabucto Bay was appreciable. Whether curtailment of this flow contributed to the observed recruitment failure and drastic decline of lobster catches in Chedabucto Bay and surrounding areas from the 1950's onward is still uncertain.

130. Modelling of Topographic Effects on Tidal Currents.

Scientific Contact:
K. Tee, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Numerical models of residual tidal currents are being developed in order to predict water movements due to tidal flows over topographic features. Results can be used to predict dispersion of pollutants, transport of sediment, and are of use in environmental impact studies.

An effective accurate computational method for modelling tidal effects has been developed, including detailed analyses of the various approximations. In future the model will be extended to include other parameters, such as stratification, and applied to coastal areas, such as the Cape Sable upwelling area, for comparison with experimental data collected there.

131. Time-Dependent Estuary Models.

Scientific Contact:
G.E. Seibert, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

Numerical models of estuarine circulation are being developed in order to examine the low frequency and baroclinic dynamics of estuaries. A long-term goal is to examine the effects of changes in the input of river runoff on estuaries such as the Gulf of the St. Lawrence.

Initial development work carried out in 1980 resulted in the construction of a two-dimensional estuarine circulation model. In future the model will be extended to three-dimensions for application to the Gulf of St. Lawrence.

132. Iceberg Drift Track Prediction.

Scientific Contact:
E.G. Bankes, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

A model was developed to compute iceberg drift, given the size and mass of an iceberg and local winds and currents. The model may be used on an offshore structure to forecast the probable track of an iceberg and the possible effects of towing efforts, or inversely to identify danger zones from which an iceberg would drift towards the structure.

During 1980 the model was tested by hindcasting the tracks of 6 icebergs observed near oil rigs on the Labrador Shelf. In 1981 towing forces will be added to the model to predict the amount of deflection of previously-modelled tracks which could be achieved by towing.

133. Oil Trajectory Analysis.

Scientific Contact:
D.J. Lawrence, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

After the Kurdistan oil spill, an extensive field program was initiated in which data on oil distribution, drifting buoy and surface drift card trajectories, ocean frontal locations and surface wind were collected and plotted in atlas form. During 1981 the Kurdistan atlas will be finished and modelling of the Kurdistan oil distribution patterns will begin.

11. ANALYTICAL TECHNOLOGY

134. Scalp Hair as an Epidemiological Monitor of Environmental Exposure - A. Chatt (p. 164).

135. Concentrations of Toxic Elements in Precipitation: LRTAP - A. Chatt (p. 165).

136. Molecular Emission Cavity Analysis (MECA) of Organohalogens - D. Stiles (p. 166).

137. Translocation and Accumulation of Elements in SPM, Soluble Fractions of Sea Water, and Bottom Sediments - A. Chatt (p. 167).

138. Translocation of Essential and Toxic Elements in Fisheries Samples - A. Chatt (p. 168).

139. ICES Quality Control Programs for Trace Metals - M. Bewers (p. 169).

140. ICES Quality Control Programs for Organic Compounds - E. Levy (p. 170).

134. Scalp Hair as an Epidemiologic Monitor of Environmental Exposure.

Scientific Contact:
A. Chatt, Trace Analysis Research Centre, Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

A combination of cyclic and conventional activation analysis methods, employing both thermal and epithermal neutrons, was developed for determining up to 35 elements in hair. Methods are being used to study hair washing procedures, metal exposure of population groups and reliability of hair trace element data.

Publication:

Chatt, A., C.A. Secord, B. Tiefenbach and R.E. Jervis. Scalp hair as a monitor of community exposure to environmental pollutants. Proc. 2nd Human Hair Symposium, the Foundation for Gynecologic Oncology, Atlanta, G.A. (in press).

135. Concentrations of Toxic Elements in Precipitation: LRTAP.

Scientific Contact:
A. Chatt, Trace Analysis Research Centre, Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

Nuclear analytical methods are being developed for simultaneous multi-element determinations in soluble and insoluble fractions of rain water, and in dry fallout samples. Conventional and cyclic INAA methods have been developed for Ag, Al, Au, Ba, Br, Ca, Ce, Cl, Co, Cr, Cu, Fe, Hg, L, K, La, Mg, Mn, Na, Rb, S, Sb, Sc, Sm, Th, Ti, V, and Zn in soluble fractions of rain water. Levels of 14 elements have been measured in the soluble fraction. Preconcentration methods for several other elements in rain are being developed.

136. Molecular Emission Cavity Analysis (MECA) of Organohalogens.

Scientific Contact:
D.A. Stiles, Professor of Chemistry, Acadia University
Wolfville, Nova Scotia.

Research in these laboratories has concentrated on using MECA to develop methods of determining total bromine and/or chlorine in a variety of organohalogens of an environmental origin. The technique is rapid and sensitive and has been applied successfully to the determination of organohalogen pesticides.

Publications:

Abdel-Kader, M.H.K., M.E. Peach, M.T. Ragab, and D.A. Stiles. The thin-layer chromatographic separation of halogenated fumigants as ammonium halides and their subsequent analysis by MECA. Anal. Letters 12(A13), 1399-1410 (1979).

Abdel-Kader, M.H.K., M.E. Peach, and D.A. Stiles. Determination of ethylene dibromide in fortified soils using a modified extraction process. J. Assoc. Off. Anal. Chem. 62, 114-118 (1979).

137. Translocation and Accumulation of Elements in SPM, Soluble Fractions of Sea Water, and Bottom Sediments.

Scientific Contact:
A. Chatt, Trace Analysis Research Centre, Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

Instrumental neutron activation analysis (INAA) methods have been developed for up to 20 elements in microgram quantities of SPM from open ocean waters. Correlations among elemental concentrations are being used to determine the nature and origin of SPM.

Instrumental methods for multi-element determination in ocean bottom sediments are being developed. Preliminary experiments indicated that concentrations of up to 43 elements may be measured.

138. Translocation of Essential and Toxic Elements in Fisheries Samples.

Scientific Contact:

A. Chatt, Trace Analysis Research Centre, Chemistry Department
Dalhousie University, Halifax, Nova Scotia.

A combination of conventional and pseudo-cyclic INAA methods have been developed for the determination of trace concentrations of 24 essential and toxic elements. A few elements were found to concentrate preferentially in liver, compared to muscle. The relationship between fish age and muscle/liver concentration is being investigated.

Publication:

Chattopadhyay, A., K.M. Ellis and K.N. DeSilva. Determination of trace elements in fisheries samples by instrumental neutron and photon activation analysis. Proc. International Symposium on Nuclear Activation Techniques in the Life Sciences, International Atomic Energy Agency, Vienna, 667 (1979).

139. ICES Quality Control Programs for Trace Metals.

Scientific Contact:
M. Bewers, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

An international intercalibration for trace metals was conducted in 78/79, in order to improve the intercomparability of trace determinations in the marine environment by different laboratories. A group of high precision laboratories was selected for an evaluation of oceanographic sampling techniques for trace metals, the next ICES intercalibration exercise.

140. ICES Quality Control Programs for Organic Compounds.

Scientific Contact:
E. Levy, Atlantic Oceanographic Laboratory
Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dartmouth, Nova Scotia.

ICES began its intercalibration activities for petroleum compounds in seawater and sediments in 1979. The objectives are to establish the intercomparability of measurements of petroleum hydrocarbon residues in the environment and, if necessary, improve and standardize sampling and analytical techniques.

The first round robin intercalibration was undertaken with sample distribution by a U.K. Fisheries Laboratory. AOL's contribution included analysis of several reference and crude oils by infrared absorption, ultraviolet absorption, ultra-violet fluorescence, packed and capillary column gas chromatography and combined gas chromatography/mass spectrometry. The analytical data have been returned to the organizers for analysis with those of other participants.

This program will continue in support of efforts to improve the intercomparability of measurements of organic pollutants in seawater and marine sediments.

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